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UK EDITION

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ON THE YEAR OF THE ROBOT

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ON THE CREATIVE ECONOMY

CARLO RATTI
ON DRIVERLESS FUTURE CITIES

PLUS 101 MORE IDEAS THAT WILL CHANGE THE WORLD

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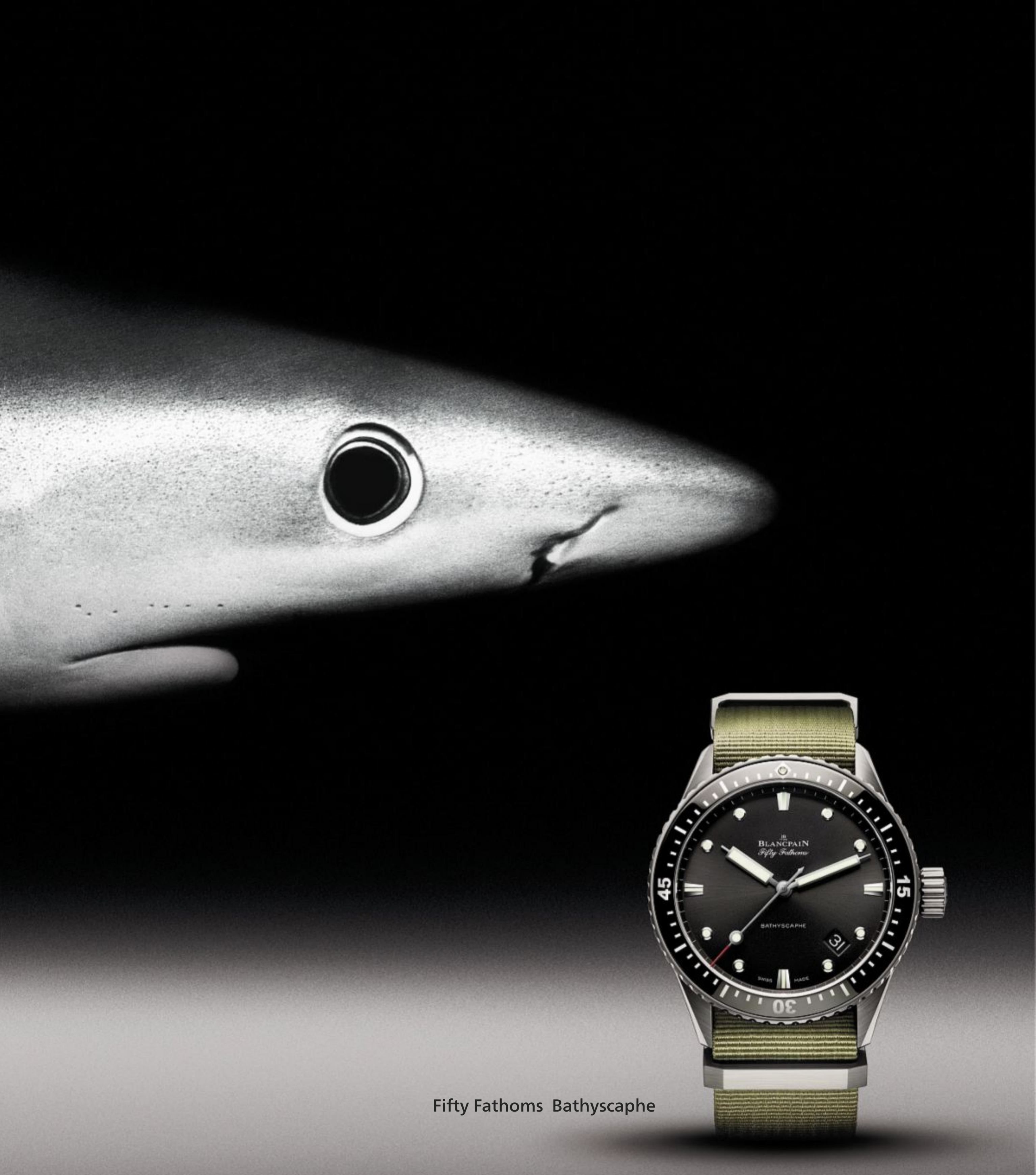

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Below: algorithms will impersonate online humans more convincingly than ever – all to manipulate us toward their agenda

ILLUSTRATION: JOE WALDRON

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DAVID BAKER

"When I was a kid," says Baker, editor of *The* WIRED *World in 2015*, "I thought robots would be doing tasks like cleaning the house and bringing us drinks while we watched TV. Now it looks as if they're also going to be taking our jobs."

For *The* WIRED *World in 2015*, he spoke to researchers, engineers, technicians and visionaries across the social and life sciences, and was struck by how much of the work we now do will be automated. "I'm wondering if we have started to lose the race against machines," he says. Baker is also a teacher of philosophy at The School of Life in London. "Luckily there are plenty of good thinkers in the world who can keep technology in its place," he says. "The brain is still the best operating system we know."

SAUL KLEIN

Klein, a partner at Index Ventures, writes about the new creative economy – where technology puts creators in the driving seat. "The wide availability of these tools doesn't necessarily mean that, in 2015, design, art, media and other creations will be any better than before," he says. "But it changes the way talent can emerge."

KEREN ELAZARI

A security expert and industry analyst, Elazari looks at how the internet itself will fare in 2015. "The web was once a symbol of democracy and decentralisation," she says. "Today we have begun to realise that a single government has exercised a disproportionate amount of control over the web – but in 2015, that will expire."

JAMES DYSON

2015 will be the year of the robot, claims the knighted British inventor and engineer. And he should know: "In manufacturing, it is robots, rather than humans, that put together machines of increasing complexity," he says. "But automating everyday tasks is even more complex, and requires a technological leap."

JOHN COATES

A former Wall Street trader and research fellow at Cambridge University, Coates examines how understanding human physiology could help steady the stock market. "When we take risk, even financial risk, we do a lot more than just think about it. We prepare for it physically," he says. "This feeds back, changing our moods."

DAN MATUTINA

Based in Metro Manila in the Philippines, Matutina illustrates the Environment section. "My favourite story is about oysters fighting climate change – it's such a cool idea," he says. "The Philippines is the third most climate-vulnerable country in the world, so this section was something I could really relate to."

LAURA CATTANEO

Living and working in Milan, Cattaneo created the illustrations for the Technology section. "I'm a big fan of technology and what it can do for us, but I know that nothing in life comes for free," she says. "Tech is a tool – any problems it creates will be from the way we are using it, not the fault of devices and software."

JOSH MCKENNA

McKenna brings his distinctive style to the Arts & Media section. "I wanted there to be a fun vibrancy to the pages," he says. "The future is so exciting – especially the role of social media in creativity. As a relative newcomer to the illustration game, I understand the importance of social media – it's instrumental in getting my work seen."

JOE WALDRON

Situated in Bristol, Waldron tackles the visuals for the Government section. "On the one hand, you have technology being used to enrich and empower citizens, but the reverse is governments using it to control and oppress," he says. "I wanted to find a balance between these two views, illustrating the positives and negatives."

PHOTOGRAPHY: MATTHIAS CLAMER; JOE MCGORTY; PETER BEAVIS

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FROM THE EDITOR

FEATURING **TECHNOLOGY / SCIENCE / MEDICINE / ENVIRONMENT / GEAR / LIFESTYLE / GOVERNMENT / ARTS & MEDIA / BUSINESS**

ILLUSTRATION: DAN MATUTINA

Welcome to the third annual WIRED guidebook to the year ahead. For the past six years, WIRED has been exploring the future as it happens: each month in our print magazine and digital apps, and every day on our website, we cover the trends, people and businesses driving the world forwards. But with this guide to the next 12 months we have the opportunity to take a more reflective look at what we see as being significant in 2015. *The* WIRED *World in 2015* is packed with future-facing ideas designed to be useful.

Inside you'll learn about the rise of neuromorphic computing and low-orbit satellites; about new medical technologies and imaginative ways to fight climate change (oysters, anyone?). Our writers address politics – from robotic propaganda to social innovation – and the arts. And, of course, business, where crypto-currencies are likely to become more central to the economy, and where consumers will expect to shop any time, anywhere.

To give reasoned assessments of which trends will matter, we've gone to our network of informed contacts. From James Dyson to Keren Elazari, Mark Miodownik to Ben Hammersley, our writers have committed to specific forecasts to explain where they see society and the economy developing. You will learn about nano-propellers and 3D-printed buildings, cancer therapies and synthetic animals. And our product editor has selected drones, robots, a helicopter and other gear that will be on our radar in the months ahead. Thanks to all our writers and those we canvassed in our search, and to David Baker and the WIRED team for pulling together this idea-packed issue.

Welcome back if you're a regular WIRED reader – your curiosity and foresight will get you far in 2015. And if you're new to WIRED, I hope you'll stay with us to experience all the other ways we tell stories. As well as the magazine – on shiny paper, tablets and phones – we run a series of high-quality events (see wired.co.uk/nextevent), a consulting business, an acclaimed podcast and, soon, a direct-to-brain edition that requires a small physical implant. Well, maybe not this year. But you can bet we're working on it.

Turn to p59 to read about the plan to dig a 200km cargo tunnel that will link Russia and the US

David Rowan

David Rowan

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Focusing on the future

THE NIGERIAN ECONOMY IS NOW AFRICA'S LARGEST. AND ITS GROWTH IS BEING DRIVEN BY AN AMBITIOUS ENTREPRENEURIAL CLASS COUPLED WITH THRIVING NATIONAL INDUSTRY

Right: Abia Imo David composes a streetside scene in Port Harcourt, home of his video production agency

Affordable student loans are scarce in Nigeria. So when Abia Imo David from Akwa Ibom State needed to fund his applied chemistry degree, he started a creative studio to raise the funds. Once he graduated, David continued the fledgling business, producing high quality music videos and photoshoots.

Nigeria is alive with entrepreneurs like David (*pictured*). Having long relied on resources such as oil and natural gas, hundreds of exciting new companies are emerging in a range of industries. More than 120 million people are mobile-phone subscribers in Nigeria and the tech sector is thriving. Startups are taking on everything from waste disposal to government transparency.

The country's GDP has recently been updated to 83 Trillion naira (£307 billion) – displacing South Africa as the continent's largest economy. Jim O'Neill, the economist who defined the BRIC economies, says the MINT nations (Mexico, Indonesia, Nigeria and Turkey) are the ones to watch now.

Despite this, entrepreneurs still face challenges. Unreliable infrastructure makes distribution difficult. Funding is scarce and training in fields such as business management is in short supply. To tackle this, Shell's LiveWIRE programme provides training and capital to founders aged 18 to 30 in the Niger Delta. Since 2003, it has trained hundreds of youths on how to start and grow a business – supplying hundreds more with seed loans.

"I was given prize money of 100,000 niara," says David, himself a LiveWIRE beneficiary. "I bought the first set of computers that transformed my business from analogue videography to digital." Abia International now turns over around 8.1m naira (£30,000) a year. It employs 17 people and David has trained many more.

SHELL / NIGERIA

Investing in youth

In 2013 Shell donated £165m to projects that support SMEs, agriculture, education and healthcare in the Niger Delta. Its other projects include:

skoool Nigeria
Education

skoool Nigeria is an interactive web-based tool for teaching maths and science in Nigerian primary and secondary schools. Shell Nigeria co-sponsors the initiative which also includes teaching aids.

LiveWIRE Nigeria
Business

The annual Shell LiveWIRE Nigeria programme provides finance and training for entrepreneurs aged 18 to 30. The initiative operates in the Niger Delta, aiming to inspire, encourage and support young businesses minds.

PHOTOGRAPHY: ANDREW ESIEBO

Joy Edojah Money, irritated by the lack of quality opticians in her region, used LiveWIRE capital to start her own clinic, Cherish. It now provides eye care to dozens of communities. Government grants and business schemes have ensured that women such as Money are empowered through work. "The prize money from LiveWIRE was a life saver. It was the first time anyone had invested in my life apart from my mum," she says. Cherish employs a team of 20 local people.

Shell is also providing micro credit to communities and has worked with banks and NGOs to help over 30,000 people establish or expand businesses. Initiatives like these and investment in education – plus the ambition of Nigeria's youth – are behind the country's new entrepreneurial class. Nigeria 2.0 is open for business.

Business development
Micro credit

Access to credit is key for any business. Since 1998, Shell's micro credit programme has donated millions of dollars to help some 30,000 people establish SMEs and expand existing businesses in the Niger Delta.

SPDC Scholarships
Higher education

Since 2010, Shell has contributed to scholarships for one-year postgraduate degrees. The scholarships help applicants from Nigeria's Bayelsa, Delta and Rivers States to develop careers in the oil and gas industry.

NIGERIA / BUSINESS

Hottest Startups

Jumia
Already being hailed as Africa's amazon.com, Nigerian e-commerce site Jumia launched in 2012 to near instant acclaim, providing over 100,000 items, from fashion and electronics to generators. This spring it launched in Uganda, its sixth international territory, and it secured more than £20 million in funding for further expansion.

Paga
Launched in 2011, Paga is a mobile payment service which allows Nigerians to transfer money and pay for purchases or bills via SMS and online. The platform has more than 1.6 million users and is licensed by the Nigerian Central Bank. It recently announced a partnership with Western Union to enable international transfers.

Wecyclers
Lagos is home to more than 18 million people, who produce some 10,000 tonnes of rubbish a day. Wecyclers' cyclists ride around the city collecting recyclable material. Participating households are rewarded via a phone-based points system which can be exchanged for goods or mobile phone top-ups.

Afrinolly
Both the Netflix and IMDB of Nollywood, Nigeria's vast cinema industry, the Lagos-based startup has become one of its biggest success stories. Users stream films and TV shows using a free app which, spurred on by the genre's popularity both in the country and worldwide, has racked up over four million downloads.

MALIYO Games
The Lagos games studio is among the first Nigerian developers to eschew clones of western titles to produce Africa-focused content. Popular titles include *Okada Ride*, named for Lagos' traffic-dodging motorcycles, and the *Mosquito Smasher* series. Games can be played on desktop computers and some newer Nokia phones.

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NEUROMORPHIC COMPUTING

The next big leap in processing power will owe less to Moore's Law than to neural networks. In 2015, our devices won't just get smarter – they'll get more human, too

By **David Hambling**

COMPUTERS ARE VERY GOOD AT crunching numbers, but nature's own neural architecture is much more efficient at parallel tasks, such as handling inputs from multiple sensors. A fly's pinhead-sized brain, for example, easily handles high-speed aerobatics that would baffle the world's most advanced autopilot. However, this will soon change with the arrival of "neuromorphic" chips that resemble living brains, and could even beat them in processing power.

Artificial neural networks have evolved over the past few decades, but they still have the same basic structure: processing elements, called nodes or neurons, are interconnected into a network, each one connecting to many others. As in the brain, the strength of connections between the neurons determines how they process an input, and these connections can be changed by the process of learning.

Until now, neural networks have been mostly the stuff of academia, but commercialised versions are about to appear. Qualcomm, the US semiconductor company, whose parts are found in almost every smartphone, is expanding its Zeroth programme, which aims to develop dedicated neural processing units.

"Our idea is to make devices 'smarter' by allowing them to process sensory data and match patterns in data in a similar way to how biological brains process things such as images or sounds, and respond," says Samir Kumar, Qualcomm director of business development.

According to Kumar, neural hardware will be able to learn from experience rather than through programming. The neural processor learns the correct response by positive reinforcement, like a dog getting a reward when it does the right thing. In a recent demonstration, a robot fitted with Zeroth processors was put into an arena marked with coloured squares. It learned to visit only the white squares through positive reinforcement, not being explicitly told to do so. Future machines will get steadily better at serving us, even when we can't quite explain what we want until we see it.

Such processors could give technology a more human-like perception of the world, enabling it to tell the difference between important mail and spam, or distinguish between stuffed toys which need tidying up and domestic pets to be left alone. A neural health monitor could tell whether pulse and respiration are normal for an individual and recognise potential danger signs. These are all difficult feats with conventional programming.

Kumar says Qualcomm aims to integrate neural processing into its Snapdragon range of processors, but could not comment on when (or even whether) this would happen. Sources outside the company, however, suggest a timescale of some time next year.

Qualcomm is developing not a hardware-based "brain" but a digital simulation of a neural network. Bio Inspired Technologies, based in Boise, Idaho, has taken a more radical route. This makes use of a component called a memristor, which comprises a wire, about a hundredth the thickness of a human hair, that changes length when electricity is applied. When the current stops, it retains its size. This length can then be read electronically: the longer the wire, the lower the electrical

THOUSANDS

-

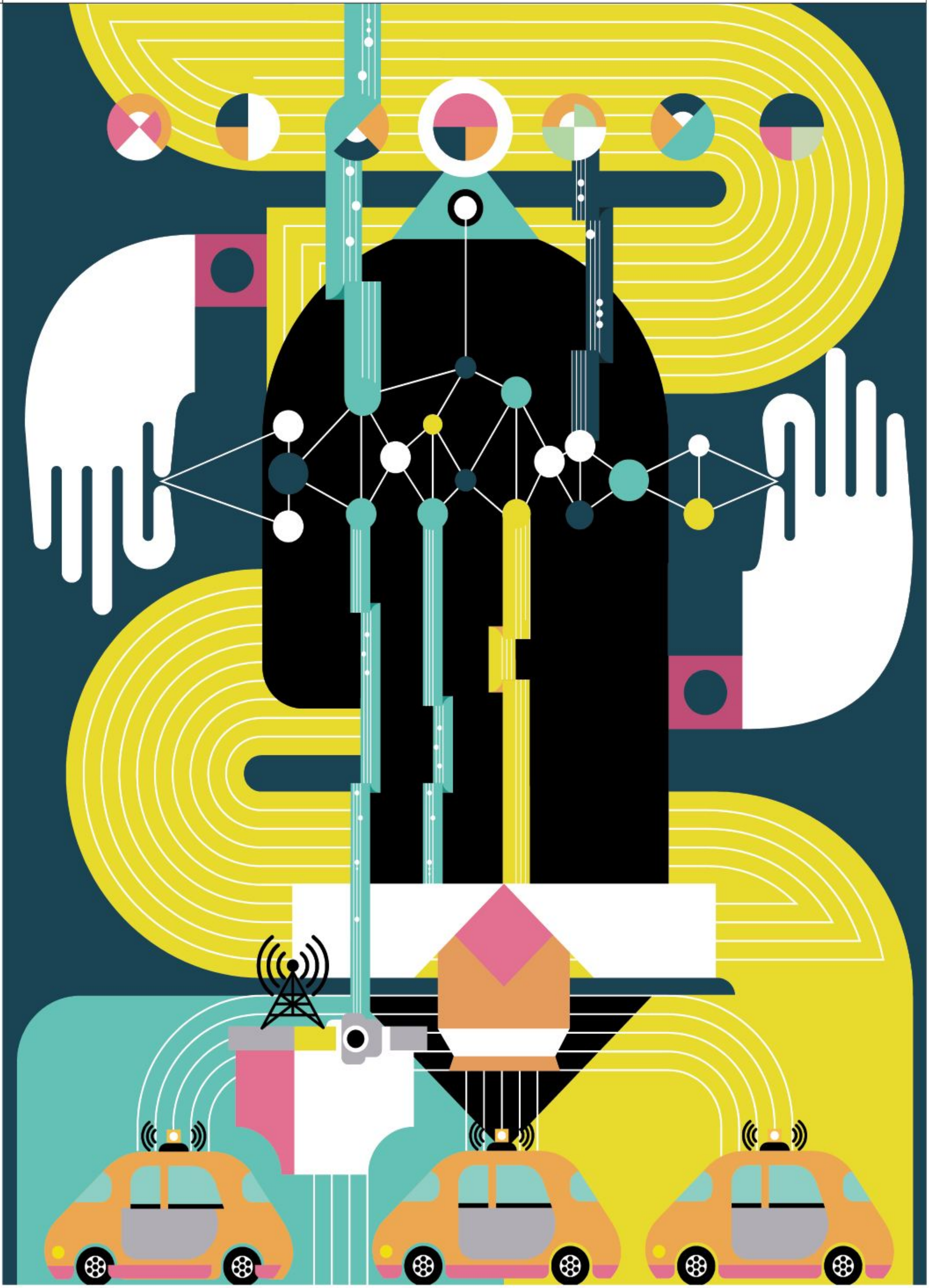
The number of cores a processor developed by researchers at MIT could comprise, by distributing data in the same way as the internet does. The blueprint will be published in 2015.

NANO PIXELS

A team at Oxford University will seek investment for a new way of producing screens with a pixel resolution of 30 x 30 nm. The ultra-high-resolution substrate can be sprayed on to flexible plastics, making it suitable for smart glasses and foldable screens. The thinner the layer, the greater the contrast that can be achieved.

SPOT ILLUSTRATION: JAMIE JONES

ILLUSTRATION: **HALFPASTWELVE**



resistance. And like a neuron in the brain, the memristor's state is determined by the sum of the signals it has experienced.

"The fascinating aspect of the memristor, and one we are capitalising on, is the uncanny similarity of this behaviour to the biological synapse," says Bio Inspired CEO Terry Gafron.

Neuromorphic hardware such as this will be essential for complex tasks in the messy real world, especially when these involve learning.

"The human brain can spot a toaster in a kitchen in less than a second, regardless of whether it is an antique or somebody has smashed it with a hammer," says Gafron. "A computer with a camera, a database full of toaster pictures and the best recognition software available can take hours – if it can do it at all."

In the automotive sector, a neuromorphic "co-driver" could learn how you drive and warn of potential accidents, telling from the way you're driving that you haven't spotted a car that just pulled out ahead of you, for instance. And when self-driving becomes commercialised, neuromorphic hardware will turn robotic awkwardness into the smoothness of a human driver. The same applies to drones, which will be able to zig-zag around each other and dodge obstacles with neuromorphic assistance.

MOTH EYES

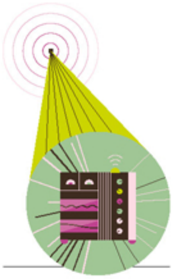
-

Photochemical cells based on moth eyes will allow low-cost artificial photosynthesis. Swiss researchers have developed the iron oxide-based cell.

"Memristors emulating the biological synapse could be used as flight-control systems that might approach insect performance-levels," explains Gafron.

There are many broader applications for neuromorphic hardware, as almost every piece of electronics could benefit from being able to recognise, adapt and learn from human requirements. It might be a television that knows your channel preferences and volume levels, or a front door that won't let a child stray out, or robot cleaners that know which areas will need attention and when, or laptops and smartphones that interact in a more human manner. You might need to tell them something twice, but after that, they've learned it.

The first neurocore devices will only have a few thousand memristors, a tiny number compared to the eighty billion-plus neurons in a human brain. But flies only need a few thousand neurons for their dizzying flight performance, so useful applications



'SINGING BOWL' CELLS

Buddhist "singing bowls" are inspiring new solar tech. Niraj Lai at the Australian National University has developed nanoscale bowls that resonate to certain frequencies of light (as the singing bowls do for sound), capturing more of the light's energy for conversion to electricity.

are within reach. Future generations of memristors will be progressively more powerful, packing ever more neurons into each chip.

"We expect a Moore's Law type of scaling," says Gafron.

This would rapidly push neuromorphic hardware up through the insect stage to more advanced life forms. Synthetic neurons also have a speed advantage over their biological counterparts and can go through processing cycles much more rapidly. The human brain operates at less than 50kHz, Bio Inspired's memristors are thousands of times faster.

"If we can successfully duplicate the performance of a brain using memristors at those speeds, the capabilities are astounding," says Gafron.

David Hambling wrote about quadrotors in The WIRED World in 2014

WHITE SPACE SPREADS THE INTERNET

The digital TV switchover didn't just improve picture quality – it left behind a chunk of bandwidth ripe for development. In 2015, 470-790MHz will become a major connector

By **Chris Baraniuk**

WIRELESS NETWORKS WILL OPEN UP connectivity in outdoor areas for both people and machines in 2015, as the radio spectrum gets a new lease of life.

470MHz to 790MHz is the sweet spot where "TV white space" lies – parts of the spectrum freed up by the move from analogue to digital television broadcasting. By the spring of 2015, the UK's communications regulator, Ofcom, is expected to finalise rules for anyone wishing to tap into those parts of the spectrum for other purposes.

Among the first practical uses of TV white space is the creation of wider and better penetrating Wi-Fi networks. This is already being demonstrated at Strathclyde University and on the Isle of Bute. In 2015 it will be used extensively to connect outdoor locations or large areas such as university campuses to the internet. TV white space will be used as the "backhaul", a signal picked up by antennae and then rebroadcast via traditional, higher-frequency 2.4 or 5GHz Wi-Fi. Connection speeds will naturally vary depending on load and the number of access points, but networks that can cover several square kilometres could provide connectivity akin to 3G or 4G mobile networks. And because white-space signals can travel further, they can be used to open up networks in previously inaccessible places. White-space radio already connects ferries travelling between the Orkney Islands to base stations on land.

The cost of TV white-space equipment is likely to fall in the next 12 months, and bandwidth capabilities will rise. This will make deploying white-space networks in remote parts of the world much more feasible. Microsoft has already set up a series of such networks in Kenya as part of its 4Afrika project. The company says the number of Africans connected via this initiative will leap from thousands to "tens of thousands" by the end of 2015.

Increasingly, however, interest in white space is being focused on internet-of-things applications. Devices connected to lower frequency white-space networks don't need as much power and can potentially last for years without requiring a battery change. Milton Keynes is building a white-space network that will allow businesses to experiment with smart objects.

There are also large commercial uses for TV white space. Mobile operators are likely to want to use these lower frequency parts of the spectrum to create "small cell" mobile networks with better connectivity in high-traffic areas.

Philip Marnick, group director of spectrum at Ofcom, says the potential of white space is almost infinite. Ofcom has overseen all the UK trials so far, including a project in Oxfordshire to measure river levels remotely so that more accurate flood warnings can be provided. There is even an initiative on one of Britain's most congested roads, the A14, which allows for fine-grained monitoring of traffic flow. "We've had all sorts of things coming through to us," comments Marnick. "I actually think that's great because what it means is people are not constrained in their thinking about how to use white space – it's a great innovation."

Chris Baraniuk reports for wired.co.uk

CONNECT FOR MERE PENNIES

The vision of billions of objects connected via the internet of things will move closer to reality if researchers at Stanford University and Berkeley can commercialise a tiny transceiver they have been developing.

Currently at prototype stage, the wireless chip, about 1mm across, harvests power from radio waves and can receive and transmit data across a range of about 50cm. It can also be produced for just a few pennies.

THE WEB: UNDER NEW OWNERSHIP

After the Edward Snowden revelations and ICANN's contract annulled, the internet is going through an upheaval. Going online in 2015 will become a different experience – depending on where you live

By **Keren Elazari**

CYBERSPACE IS NOT A SERIES OF tubes or an “information superhighway”. It’s a layer of reality that offers the means to access and control the real world. Numerous organisations exercise control over it: from the web giants of Silicon Valley to the National Security Agency. And most of them are based in the US. But in 2015, this mostly US control of the internet will end.

The web was once a symbol of democracy and decentralisation. Today we have begun to realise that a single government – the driving force behind the creation of the internet – has exercised a disproportional amount of control over the web.

In March 2014, the US Department of Commerce (DoC), stung by world reaction to Edward Snowden’s NSA revelations, announced that it would not renew its contract with the Internet Corporation for Assigned Names and Numbers (ICANN). Since 1998, ICANN has been managing the web’s Domain Name System and the IP numbering network from an office building in Los Angeles, California. The contract, which involves no funding, allows for privatised control over DNS and IP.

In September 2015, the contract will expire. Control and responsibility over these foundational systems will shift to new masters – the global community. The DoC has stated it will not accept a solution that places another government organisation, or even an inter-governmental organisation, in control. This follows a long-standing battle it has had with the United Nations International Telecommunication Union (ITU). And there are other players afoot. Facebook and Google are creating new internet-access ventures for the “unconnected” billions. Nations such as Brazil and China are contemplating building a web of their own by setting up alternative DNS root servers, or simply by exercising more control over web traffic within their national boundaries. Privacy-minded European leaders, such as Germany’s Angela Merkel, have also made declarations about the need for EU alternatives to a US-controlled internet, such as a “private EU cloud”.

ICANN currently controls the internet’s “DNS root zone file” – a database listing all of the top-level domain names (such as *.com and *.co.uk) and the IP addresses that allow a computer to fetch pages from the correct domains.

21,250 METRES

-

The altitude at which Facebook will be testing drones, the size of commercial aircraft, that could bring the internet to so-far unconnected places. The planes will have to fly for months at a time.

In 2015, ICANN will lose this role, though it is as yet unclear who will take over. The issue is being debated at conferences and in government departments, but a truly multiple-stakeholder governance solution has yet to emerge. What is certain is that this fundamental change will open the gates to more non-US players – including NGOs, corporates and nation-states – to take back control, or gain new types of control, over the internet’s infrastructure.

The effect of this change could go in either of two, opposite directions. On the one hand, removing this bastion of US government control over the internet could lead to a truly globalised web, something more akin to the founders’ vision for the internet. On the other, it could spawn a Balkanised internet in which different rules apply in different countries. Either way, by September 2015, the future shape of the internet will be forged.

Keren Elazari is an industry analyst at Gigaom Research, an independent source covering emerging technologies and trends

2015: THE YEAR OF THE ROBOT

Sure, they will replace plenty of mundane human jobs – but increasingly intelligent machines will need plenty of engineers and smart researchers

By **James Dyson**

THE ROBOTS ARE COMING. IN 2015, the world will belong to intelligent machines – high performing and autonomous. So far, robots have only touched our lives as science-fictional characters. In the real world, they've been disappointing both in performance and fearsomeness – machines that sing and dance and end up on children's Christmas wish-lists. Gimmicks.

We all expected robots to be everywhere by now – and in some senses they are. In manufacturing it is robots, rather than humans, that put together machines of increasing complexity. Robot arms are more precise than human arms – that's why, at Dyson, we use 50 robots to delicately assemble each one of our digital motors.

The challenge is untethering these robots and allowing them to roam free. The factory floor is very different to the ever changing environments that exist beyond. I should know. I've spent 16 years developing a robotic vacuum cleaner capable of actually cleaning (current robot sweepers are the equivalent of a staggering housemaid flicking around dust and bouncing about the room – fun to look at, but not much good at their job). Automating everyday tasks is complex, costly and requires technological leaps rather than small improvements.

Lives will change beyond cleaning. Winding their way around Milton Keynes and Palo Alto, robotic cars will hail a driverless future. Drones will revolutionise industry. The implications will be broader than quicker pizza delivery; remote disaster-struck areas will get medicine and vital supplies. Already in Kenya, drones keep a watchful eye out for poachers after rhino horns.

Nature and robotics will go hand in hand. Researchers at Sheffield University are mimicking the GPS system of the honeybee, and a Harvard team is creating thousands of tiny robots capable of acting collectively. Hive robots will tackle everything from environmental clean-ups to disaster response.

It's clever, but real leaps will come once these mechanical and robotic systems are given vision. Seeing and understanding are two different things. Knowing the difference between a Coke can and slipper isn't easy for a robot. We need machines that can see the world the same way we do.

Intelligent machines won't just be the result of robotic technology. They will be underpinned by advances in batteries, material science and motor research. Graphene and carbon nanotubes will creep into more products. Longer-lasting batteries will be married with smaller, faster digital motors. The plug and cord are headed for extinction.

All of this won't just change the world in 2015 – it will change the world years from now. A generation of engineers is emerging who are inspired by new technology and the possibility of invention. Forget *The X Factor* – 2015 will be the year robotic X-projects take the limelight. A good job, too. After all, although jobs will be lost to this robotic revolution, millions more will be created in research and development roles. We'll need engineers by the bucketload.

James Dyson is the founder of Dyson. He wrote about transportation in The WIRED World in 2014

ROBOT SMILE

Pepper, a 121cm-tall emotion-reading robot from Aldebaran, will go on sale in 2015. Its two colour-video cameras and four mics can "read" the facial expressions and vocal tones of people around it.

10GBPS

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Li-Fi (light-powered internet) speed achieved by Mexican company Sisoft. Previously, experimental systems had only achieved speeds of up to 1.6Gbps.

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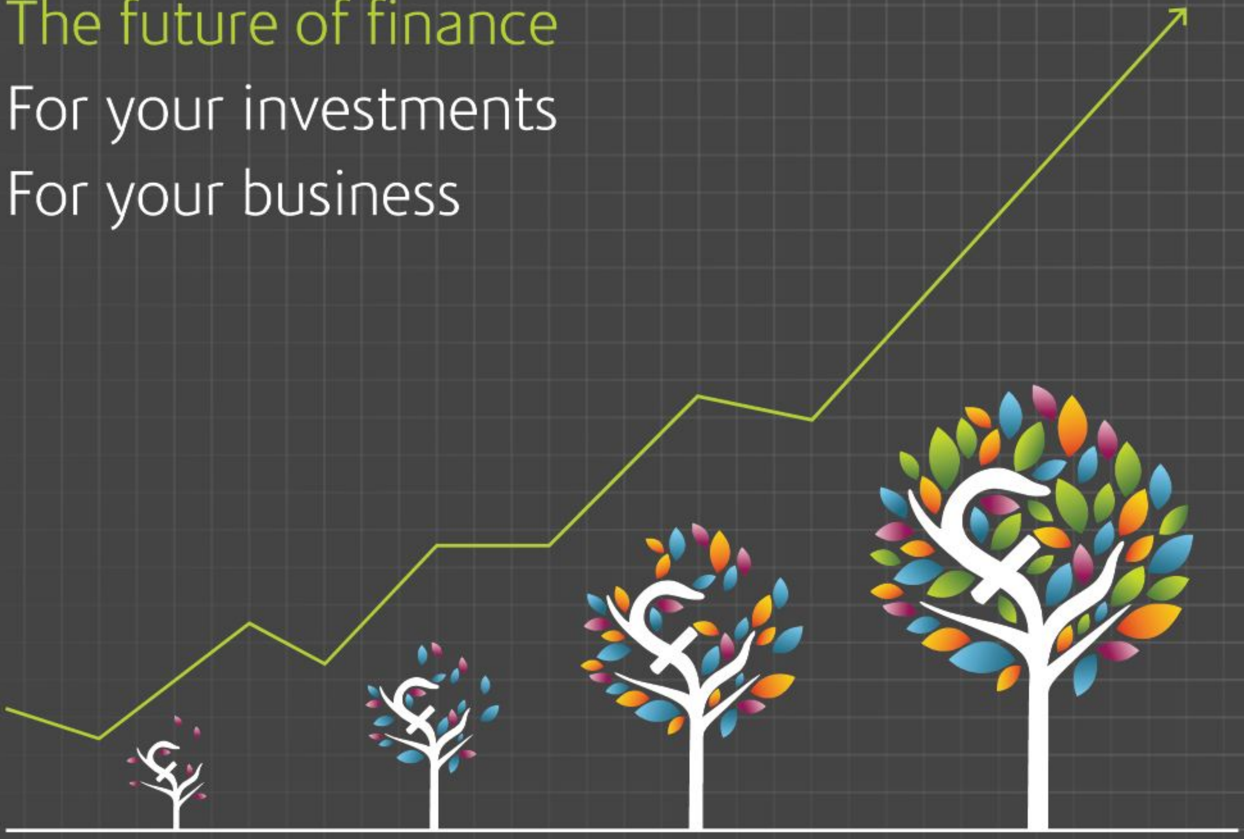

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NANOPRINTING SCALES UP

Move over, 3D printing – the hot new process in 2015 will be nanoscale manufacture. Capable of creating a range of products, it will be cheap enough for startups to get in on the action

By **Ahmed Busnaina**

ALTHOUGH 3D PRINTING WAS ALL THE rage in 2014, for business and manufacturing 2015 will be the year of the nanoprinter. Nanoelements have unique and superior properties. The mass production of devices and nanostructures – using nanoparticles, nanotubes, quantum dots and other minuscule building blocks – will lead to new technologies in electronics, biopharma, medicine, energy and beyond.

Researchers are already exploring nanomanufacturing, but hurdles include the high costs of production and fabrication. The US National Science Foundation's Center for High-rate Nanomanufacturing is developing new methods that, in 2015, will allow industry to produce mass quantities of high-quality nanoscale products at low cost. The team has developed a Nanoscale Offset Printing System (NanoOPS), which can print nanoscale structures and circuits as small as 25 nm (more than 1,000 times thinner than a human hair) on to a variety of surfaces.

In 2015, NanoOPS will be printing nanosensors for the early detection of cancer; customised oral medications; high-performance flexible electronics; wallpaper that can double as a television screen; thin, flexible and lightweight batteries; and energy-harvesting fabrics that could power laptops or phones.

Nanoprinting can be done 100-1,000 times faster than current inkjet-based electronic and 3D printing. Its print process uses templates fabricated using conventional nano and microfabrication techniques. Each template has embedded nano and micro wires that follow the pattern to be printed.

The printing process has two steps: first is inking of the template, which is done by using directed assembly of nanomaterials (ink particles such as nanoparticles, nanotubes, polymers, etc), by placing the template in a suspension (ink) containing the nanomaterials (ink particles), and applying an electric field through the nanowires (and a counter electrode) to attract the nanomaterials and molecules to assemble only on these wires.

The second step is the printing, which is done by transferring the assembled structure or circuit on the template to another substrate. Each step takes about a minute, regardless of the density or scale of the pattern. The steps take place at room temperature and pressure, and the ink can include mixtures of nanomaterials suspended mostly in water, thus also offering substantial energy savings and a cleaner approach.

NanoOPS will operate at up to one-hundredth of today's electronics nanofabrication cost, making nanotechnology and nanomanufacturing readily accessible for startups and other small businesses. A current nanofabrication facility can cost the developer billions of pounds. A facility based on NanoOPS will be closer to tens of millions.

This will unleash innovation in the materials field, much as the personal computer did for computing, the internet and mobile communications.

Ahmed Busnaina is William Lincoln Smith chair professor, The NSF Nanoscale Science and Engineering Center for High-rate Nanomanufacturing at Northeastern University in Boston

SQUEEZED

-

A phase-change material developed by a team at MIT will make robots move like octopuses, becoming alternately flexible or rigid when needed.

LOW-ORBIT SATELLITES

A new stream of real-time data about our planet will make its debut in 2015 – beamed in 24-7 from a meshed network of nano-satellites circling the globe

By **João Medeiros**

CONSTELLATIONS OF LOW-ORBIT satellites that monitor the Earth in real time could bring new understanding of everything from war to epidemics. But until now the high cost has been the limitation. In 2015 Satellogic, an Argentinian startup, plans to change that with 15 satellites streaming live, high-resolution images and video from space. Three are in position at the time of writing – a planned 300 could be in orbit by 2017.

"We're building a sensor network focused on the planet," says Satellogic's CEO and founder, Emiliano Kargieman. "I call it the Quantified Earth movement."

Kargieman, who founded computer-security company Core Security Technologies, had the idea for Satellogic in 2010. "I came from the software industry where we focus on agile development," he says. "Aerospace was different: large, upfront investments, and it's monolithic. There are so many problems we can solve with satellite data, yet the capabilities of the space industry are behind what we need."

Satellogic, whose HQ is in Palo Alto and which has offices in France, Israel and Argentina, uses rapid prototyping, commercial electronics and off-the-shelf parts. Its nano-satellites are about 100 times cheaper than standard satellites.

"We've raised $7 million from investors," he says. "We have three satellites in space. A lot of internet companies needed more funding to get started."

Each nano-satellite weighs about 40kg, is the size of desktop PC, and has a multispectral camera with a 1m resolution from an altitude of 600km. Satellogic's constellation will be able to stream data in real-time thanks to its mesh geometrical pattern. There have been satellites with crosslinks (the Iridium constellation), but Kargieman's project will be the first to use mesh network topology, used by all the satellites in the system to share storage and processing power. "We'll always have access to any satellite on our network at any time," he says. "Standard satellites only have about half an hour of contact with ground stations every 24 hours."

Satellogic is not alone in low Earth-orbit. Planet Labs, also founded in 2010, plans to launch 131 nano-satellites by 2015; Palo Alto-based Skybox was acquired by Google in June for $500m.

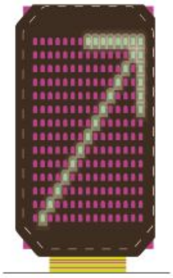
"Google's move was great validation for our industry," says Kargieman.

Satellogic is working with customers from the agriculture and oil and gas industries, but can't yet disclose names. "Agriculture will become data-driven," says Kargieman. "For a long time, farmers have relied on heuristics and incomplete information from ground measurements. Satellite data will allow us to monitor biomass, track plagues and bugs, and predict yields."

Beyond 2015, Kargieman sees satellite data used in food distribution, management of natural resources, disaster response and border control.

"Space is sexy and everybody loves to talk about it," he says. "We're trying to occupy space in a different way, using space to tackle big problems on Earth."

João Medeiros is WIRED*'s science editor*



57 PER CENT

The increase in brightness achieved by the nano LEDs that a team at Princeton University has developed – and hopes to commercialise in 2015. In conventional LEDs, most of the light produced becomes trapped by the surrounding structure.

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BECOME A TECH TRIBE MEMBER

From Sony to Apple, consumer brands will attract ever greater loyalty – but only if the manufacturers can create compelling ecosystems that work across many devices

By **Shahid Hussain**

THE INTERNET BRIEFLY PROMISED the triumph of the long tail: small, independent products providing us with a customised user experience. In 2015, however, it will be like the old days again: we will all belong to a company tribe – Apple, Google, Microsoft, Amazon or Samsung, plus some smaller players – but we'll be pretty much part of one system or another.

In the 90s, mobile-phone customers were loyal to their carriers. This was because it was cheap to call inside a network but expensive to call between them. So our choice of network was determined largely by the people we knew and called often. Today you can use your minutes to call anyone; people choose networks based on other factors, such as who has the best handset. But as we add other devices to our personal collection, we are going to start thinking again about compatibility – not so much how we talk to our friends, but how our devices talk to each other and the services they can access.

In the developed world, many of us are now surrounded by an array of computer-based technologies – smartphones, laptops, tablets, TVs and gaming consoles. In 2015 we'll add smart-home automation and wearables to that list. And that's when we'll start to think about how all these devices interconnect and about the services that lie behind them – email, music, search, productivity tools and others we can't imagine right now. And they will need to run across all our hardware. Whereas today, it's no big deal to use, say, Google's Chrome browser on your iPhone or Apple's iTunes on a Windows PC, in 2015, as systems become more complex, people will begin to see the benefit of using Company X's stuff with Company X's other stuff.

Firms such as Apple and Samsung for smartphones, Amazon for cloud-based services and Microsoft or Sony in console gaming are already advocating the advantages of this tribal lock-in. In each case there's an increasing benefit to buying into the same ecosystem. If you're an Amazon customer, buying one of its Fire phones would make it even easier to find what you need, and you know for sure your Amazon Prime video is going to work well with it.

There are risks of course. Sony's PS4 may be a great gaming experience, but other services are lacking (even music, which you might expect to be a strength). By contrast, Microsoft has Xbox Music, which works very nicely with Windows and Windows Mobile, meaning that we consumers get a better product and Microsoft bigger profits: every Xbox One sold is an opportunity to capture revenue in other areas.

Look out in 2015 for a retro flashback to the early days of mobile. Just as we were once Orange people or T-Mobile people, next year we'll be Amazon people, Google people, Apple people.

I, for one, will welcome our new technology overlords.

Shahid Hussain has worked extensively in technology product marketing, and wrote The No Bullshit Guide to Product Management

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SCIENCE

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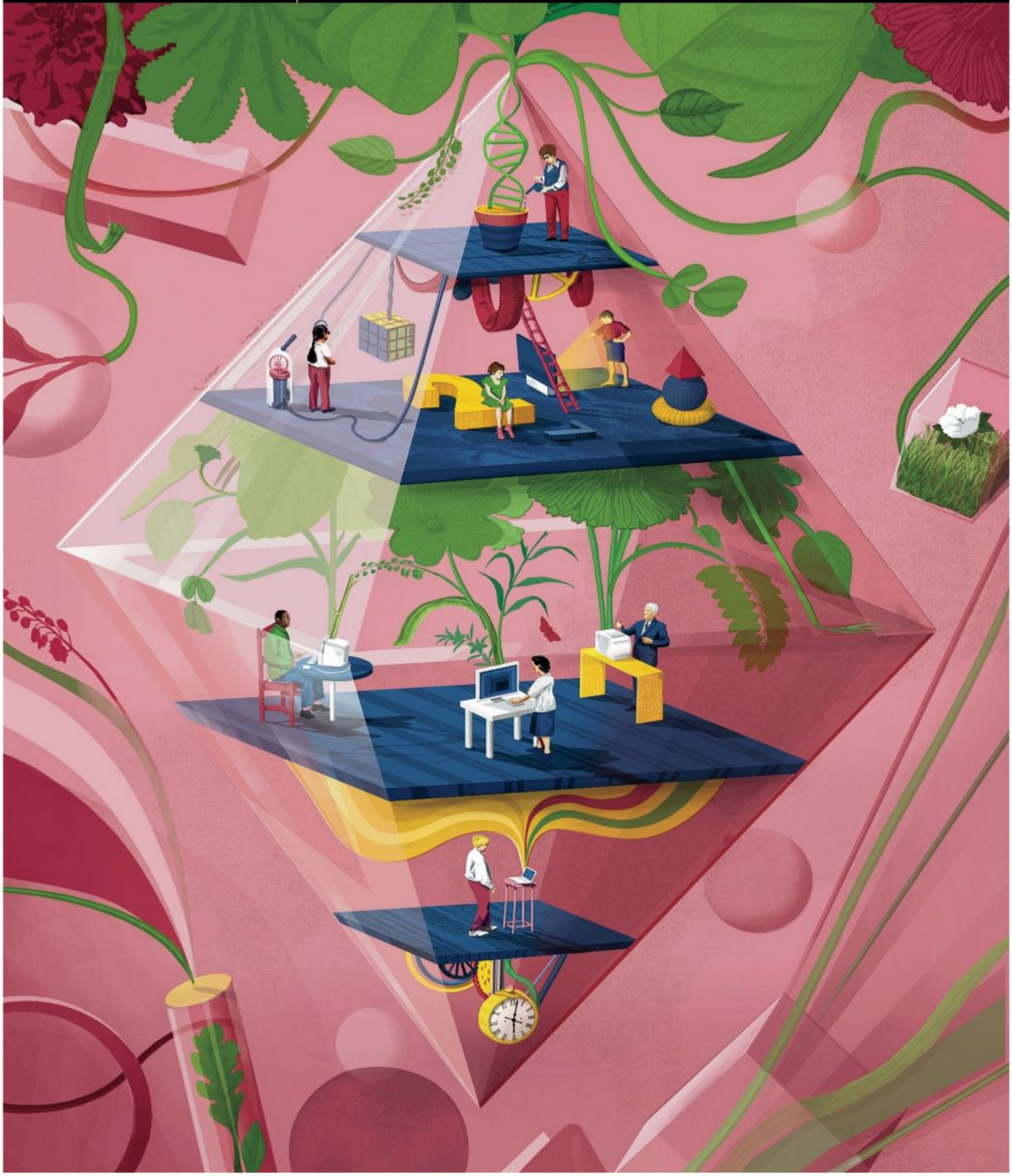
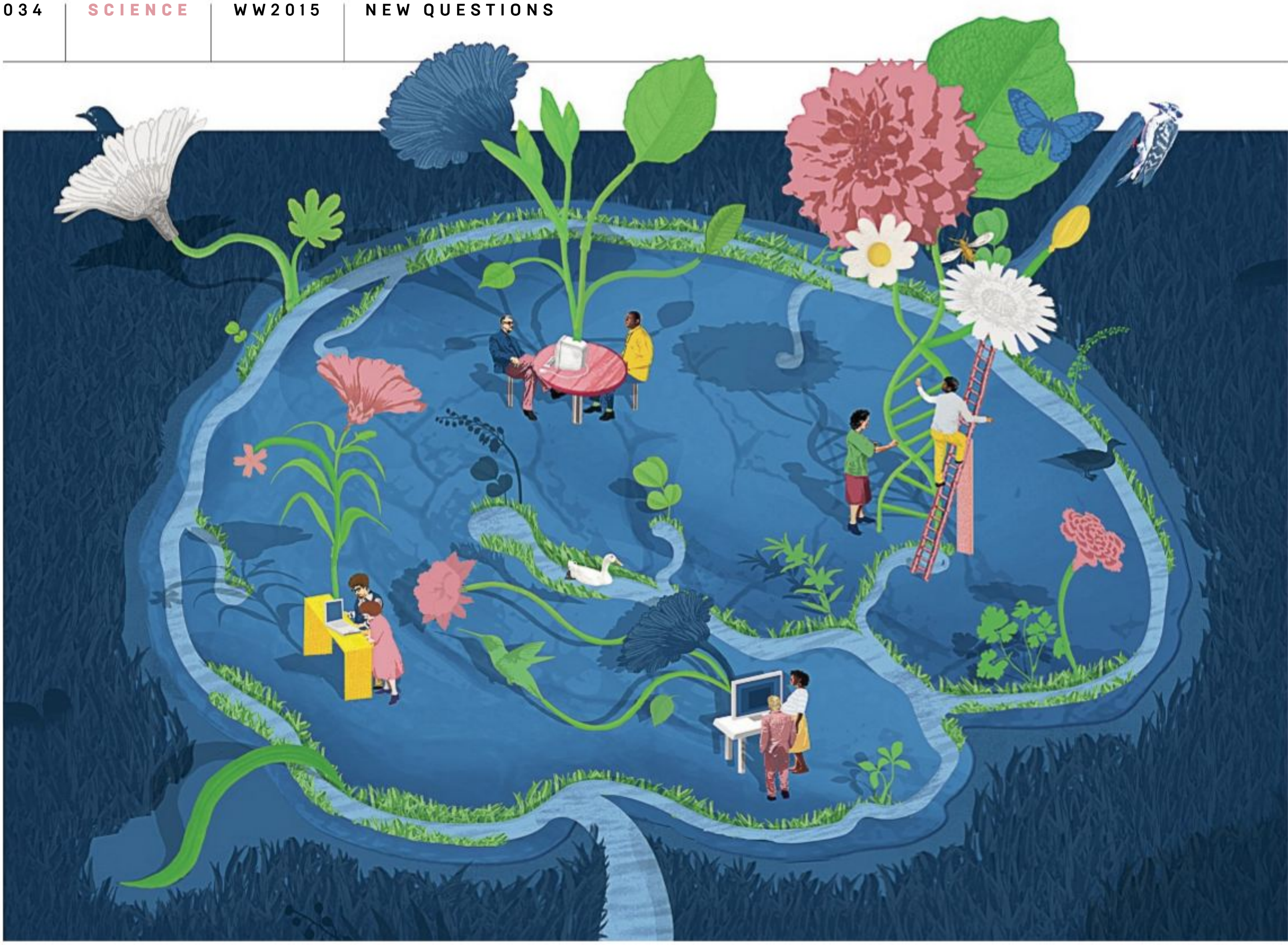




BUSINESS BRAINS GET THINKING

With detailed metrics pouring in from every direction, businesses have never had so much insight. 2015 will be the year they learn to ask their data the right questions

By **Hal Gregersen**

THE GREATER THE DATA WE HAVE, the harder it is going to be to discover its implications. In 2015, a new approach to analysis – catalytic questioning – will give business leaders fresh insights that will transform markets.

Catalytic questioning is an alternative to brainstorming whereby your team can do question-centric work. Pick a problem that your team cares deeply about and ask nothing but questions (no answers allowed) until you reach at least 50. Once you've done this, step back and determine three or four questions that are the most "catalytic" – the startling ones that force you to change your perspective. Seek solutions to these questions until you uncover extraordinary insights and answers.

One way catalytic questioning can help a company transform its business with big data is by asking: "What story is the data telling us?" Consider SAP.

SAP data scientists worked with a major transportation company that was struggling to understand what was impacting its financial performance, and to predict where the market was heading. Using catalytic questioning, SAP brainstormed with executives. From those questions the data scientists developed forecasting models to analyse more than 48,000 combinations of "products shipped x location x customer" that were validated against thousands of macro-economic factors, competitive data and customer

ILLUSTRATION: SAM FALCONER

LEVITATING TRAINS

-

A Cambridge team will commercialise a cheap, efficient high-temperature semiconductor for maglev trains. The material can trap a record-breaking electric field of 17.6 Tesla.

sentiment. Fuelled by uncommon questions and big data, this company is now predicting future outcomes and competing more successfully.

In the not-too-distant future, we may see artificial intelligence actively engaged in catalytic questioning. By tracking subtle human cues (heart rate, etc) it may provide instant feedback for a group to generate new questions. But machines will not be able to truly read emotion, at least in the next decade or two, so they can't completely duplicate catalytic questioning. This process is inherently a creative one that's meant to convert raw numbers into ripe understanding and solutions. Beyond providing a unique perspective on how to achieve a goal, this process can also uncover whether the original goal is even worth pursuing.

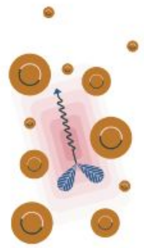
If world leaders learn to ask novel new questions, big data can enable them to solve some of the planet's most vexing challenges. Researchers, for example, have often depended on physical observation to understand Earth's biodiversity and the interrelationship of species. However, by using data from DNA testing, combined with environmental findings, researchers with the Barcode of Life project can now ask questions such as, "What species of plant did a specific caterpillar feed on, and what parasites fed on the caterpillar?"

Understanding the various food webs will be critical to protecting biodiversity and our future food supply.

2015 will be the year when big questions will force big leaders to challenge big assumptions that perpetuate big, enduring problems. If leaders fail to ask new, uncomfortable, emotionally charged questions, we will live out the same old answers – no matter how big the data sets become.

Hal Gregersen is executive director of the MIT Sloan Leadership Centre

SPOT ILLUSTRATION: JAMIE JONES



NANO PROPELLER

Nano materials will be able to travel through fluids thanks to a propeller-like structure developed by researchers in Israel and Germany. The team has built a tiny corkscrew, 70 nm-wide and 400 nm-long, and made of silica and nickel, which is powered by an external magnetic field. This will allow it to propel its payload through bodily fluids such as blood and deliver it to a precise location in the body. In vivo tests will begin in 2015.

DIPLOMACY IN SPACE

Off-planet relations become the new final frontier as the US, Russia, China and Europe work to find ways of co-existing in orbit

By **AN Hash**

BY MARCH 2015, US ASTRONAUT Scott Kelly and Russian cosmonaut Mikhail Kornienko will have begun a US-Russian one-year mission aboard the International Space Station (ISS).

Instead of the standard six months, the two men plan to spend an entire year circling Earth. By monitoring the two men over a longer period of time than usual, medical researchers hope to get a better understanding of the physiological damage suffered by humans in space. The aim is to devise ways of protecting humans living in space for long periods, with an obvious glance to future missions to Mars.

Whether the mission succeeds, or even runs its full term, depends less on the science of health risks, however, and more on the political situation down on Earth. The key question in 2015 will be how viable a multinational space station led by the US really is?

The US is lead nation: it pays the most annually to keep the station running. But the ISS is a joint venture. Russia, Canada, Japan and the European Space Agency contribute substantially to its running costs. As partners in space, they also depend on each other more than many of their politicians on Earth would like.

At the most fundamental level, ISS crew members depend on the station's Environmental Control and Life Support System (ECLSS). This provides critical life support: the air, water and food needed to keep the humans on board alive. Both US and Russians systems are used and, in many cases, this means that redundancy is built in: one side's sub-system can cover for the other's in the event of any major system failure. The Russian segment depends on electricity generated by US solar arrays; it stays orientated using data drawn from US satellites and gyroscopes.

Since axing its ageing Space Shuttle fleet in 2011, the US depends on Russian help to reach the station. For Roscosmos, the cash-strapped Russian Federal Space Agency, an astronaut on one of its Soyuz spacecraft taking the six-hour trip to the ISS brings in over $70 million (£41m).

In 2015 this balance of dependency will end. The renewed rattling of sabres over the Ukraine and the political changes driving the situation there, the international scramble for resources and the rejigging of the global calculus of power as China comes to the fore, are all affecting the special relationship between the Americans and Russians.

There's a deeper recalibration going on in Washington and Moscow too – a move away from the idea of economic globalisation and a return to the notion of the geopolitical importance of the Eurasian heartland as a way of understanding how the world turns.

What seemed to signpost the start of a post-Cold War global order – the meshing together of states in a wired, highly interconnected global network – is increasingly regarded as a source of systemic weaknesses.

Stung by American sanctions, Russia's deputy prime minister Dmitry Rogozin tweeted last April: "I suggest the US delivers its astronauts to the ISS with a trampoline."

It's an empty threat, of course. The Russians know that the US is entering a new space age, with its commercial sector already delivering supplies to the ISS. In 2015, Orbital Sciences plans three trips with its Cygnus cargo ships. Elon Musk's SpaceX plans four visits with its Dragon capsules. By 2017, NASA hopes to ferry all its ISS crew using US commercial spacecraft, cutting the Russians out completely.

Meanwhile, excluded from the ISS by the US, China is planning its own space laboratory in 2015 – Tiangong 2 ("Heavenly Palace 2") – with plans for a space station to follow in 2020. The Russians and the Europeans are already keen to join.

AN Hash wrote about friendly drones in The WIRED World in 2014

STUCK

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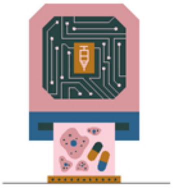
A team at the University of Newcastle has discovered how barnacles attach themselves so securely to ships' hulls. The technique will be used to develop in-body medical glues.



ARTIFICIAL ANIMALS

Science will take a further step towards the end of animal testing with an "organ on a chip" developed by a team at Harvard's Wyss Institute for Biologically Inspired Engineering. The size of a USB stick, the device can be loaded with living human cells cultured to mimic their behaviour in the body. These can then be exposed to drugs, chemicals and cosmetics, and their reaction monitored.

TEENAGERS TAKE ON THE TECH WORLD

If you haven't launched a startup by age 15, you're already lagging behind. 2015 will be the year where the freshest, most exciting ideas come straight from the source – young people

By **Stephen Haag**

TEENAGERS AND PERHAPS EVEN pre-teens will be among the leading innovators and inventors in the tech space in 2015 – so much so that we will see a growing emergence of millionaires who aren't old enough to drive.

The trend has begun. In the UK, Nick D'Aloisio launched his iOS app *Trimit* in March 2011, when he was 15. Two years later he sold it, renamed *Summly*, to Yahoo! for a reported $30 million.

In the US, at 16, Juliette Brindak started Miss O & Friends, a girls-only social networking site for tweens. According to early investor Procter & Gamble, the site was worth $15 million in 2012.

Also in the US, Cameron Johnson started his entrepreneurial ventures at the age of five by selling vegetables to his neighbours. He then launched Cheers and Tears, a greeting-card company that earned him $50,000 per year by the age of 12. By 15, he was earning up to $400,000 per month, due mainly to his online advertisement service Surfingprizes.com.

Teens such as these have benefited from the low-risk, high-reward environment of internet business, unhampered by the traditional baggage and concerns of adult life, in particular the way traditional university education emphasises scepticism over creativity. By the time most adults leave university, they have developed the ability to show why an idea isn't wrong instead of focusing on why an idea is right. That may seem subtle, but it's significant in the entrepreneurial space.

Teenagers haven't yet heard "no" often enough not to believe that every idea is a great one.

The same applies to business. In traditional business practices and planning, people are taught to avoid risk and

0.16MG/CM^3

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The density of a hyperstrong aerogel to be commercialised by scientists at MIT and Lawrence Livermore National Laboratory, which can withstand loads 160,000 times its own weight.

uncertainty. In short, they try to predict the future based on historical data. That approach doesn't work in the tech world, especially for market-creating products and services such as *Snapchat*, *Instagram* and Facebook. Today's youth do not look backward; they look forward to invent. As such, they see risk and uncertainty as a normal market condition, and they embrace it to create change.

Teenagers will also be less exposed to the financial risk of a project, as the costs of developing and launching a technology product – especially if web-based – fall to almost zero. And they have more resources to devote to their idea. As people get older, an "all-in" bet on an entrepreneurial venture can have a significant downside: the loss of a consistent income, less time with family, and potentially the loss of savings. Teenagers don't face those obstacles. When there is little or nothing to lose, an "all-in" bet on a venture is nothing more than, at worst, time wasted on something that doesn't work out.

Technology, especially software, is the ideal space for entrepreneurship. With some skill in development in HTML5, CSS, Python, Objective-C, Java and the like, anyone can start a tech business with little capital investment. Moreover, the marketing and distribution costs for an app or web-based service are almost zero. When fixed costs are low, the barriers to entry in an industry are greatly minimised. Even a teenager with no capital can get in the game and compete against the giants.

Stephen Haag is associate professor-in-residence at Daniels Business College, University of Denver

EDUCATION GOES ELECTRIC

Children struggling with maths will be having their brains rewired for mental calculation in 2015, thanks to a combination of cognitive exercises and neural stimulation techniques

By **João Medeiros**

A CHANGE IS TAKING PLACE IN education. In 2015 we will start thinking less about how much information we dump in children's brains and instead focus on how technology can empower their brains to be stronger and faster, overcoming any weaknesses they might have. New techniques of electrical brain stimulation, combined with cognitive training, will make education smarter.

Torkel Klingberg, a professor at the Karolinska Institute, Stockholm, and founder of Swedish cognitive-game company Cogmed, has developed a series of gamified computer exercises for children to improve their working memory. These use a variation on standard cognitive-training exercises – such as the "backwards digit span" challenge, in which a child has to type a list of numbers that was shown on the screen that are simultaneously read aloud, but in reverse order.

"I have also recently made a meta-analysis of the effects of working-memory training on attention in everyday life," says Klingberg. "A summary of 13 studies shows clearly that training improves attention in everyday situations." In 2015, Klingberg will study six-year-olds, looking to explain what differences in their brains and their genes allow some to improve more than others from such training.

A number of researchers are now combining these tools with brain stimulation using electric currents. One example is the work of Roi Cohen Kadosh, a researcher at the University of Cambridge. Cohen Kadosh uses cognitive training tools in conjunction with transcranial direct current stimulation, a method that applies a very low direct current to the brain to stimulate the plasticity in certain regions. In 2015, he will publish the results of a study being conducted with German "mental calculator" Gert Mittring.

"The brain stimulation increases the likelihood of plasticity," says Cohen Kadosh. "I think that the combination of brain stimulation with cognitive training can lead to better results." One of the focuses of Cohen Kadosh's research is the neural mechanisms behind how we use numerical information. He claims our mental representation of numbers happens via the physical embodiment of quantities.

"What do we use when we first start counting? Our fingers," he says. "Cognitive psychologists have shown that we represent numbers on a mental number line. What happens with people with poor mathematical ability is that the physical representation of numbers along that line is very inaccurate."

Cohen Kadosh has written a prototype iPad game to tackle this problem: the player is given a fraction, say 3/4, and has to indicate where, within a margin of error represented by a tiny bar, that fraction lies in a straight line that goes from zero to one. As the game progresses, the fractions became increasingly harder to compute.

"We've recently developed that game for the Kinect, so that the physical embodiment of numbers is made with

your whole body in motion," Cohen Kadosh says. "When we had our first subject, I wanted to be present in the room to make sure everything went smoothly, but she felt uncomfortable that someone was watching her trying to solve numerical problems.

"When the game finished, she came back and said, 'I loved it. I want to take it home.' This is from someone who hated maths." In 2015, Cohen Kadosh will continue to examine maths training inside and outside classrooms.

"Combining cognitive training with brain stimulation in the case of children with atypical development," says Cohen Kadosh, "that's my view of the future in the field of education."

João Medeiros is WIRED's *science editor*

1,000X

-

The increase in computing speed that is promised by replacing silicon in processors with phase-change materials, following research at the University of Cambridge.

NUCLEAR BATTERIES

Researchers at the University of Missouri will be real-world testing a nuclear battery based on radiolysis – splitting water with radiation to produce energy. The team's water-based battery incorporates a nanosize titanium dioxide catalyst which assists the radiation in breaking down water molecules. The result: far greater efficiency.

TEMPORAL REORDERING

Our linear relationship with time affects everything from financial transactions to scientific progress. In 2015, we will throw out the old model and learn to look backwards to move forwards

By **Jimena Canales**

OUR NOTIONS OF TIME IN PHYSICS, philosophy and history are changing. One of the most entrenched notions about the world considers time as linear and homogeneous – as a container where events succeed one after the other according to the laws of causality. Albert Einstein famously defended this conception of time.

Even as Einstein's theory of relativity continued to succeed, numerous thinkers baulked at the mere thought of having to consider time in this way.

"Einstein's imagination failed him," explained Lee Smolin of the Perimeter Institute for Theoretical Physics in Ontario in his book, *Time Reborn*. "It does not seem to have occurred to him to conceive of the universe as anything but static and eternal."

As we refine our theories of time, we will see that to act on the future, one needs to start by changing the past.

Will the theories of tomorrow trump the theories of today? The advancement of science, and the billions of pounds poured into R&D, would come to a dead halt if we didn't think it would. Our faith in the power and benefits of science depend on a particular notion of time – where the present moment is at the peak of our current knowledge of the world. The ultimate narcissism of our scientific culture is our belief that just by virtue of being at the peak of time, we know more than anyone who came before us.

In 2015 we will reconsider the value of ancient wisdom and low-tech solutions. Big data has shown us the need to be aware of the danger – and opportunity – of advancing science by removing knowledge from the public sphere. To succeed today, one must know what someone else does not know. Agnotology, the study of culturally induced ignorance, is now as relevant as epistemology, the theory of knowledge.

In 2015, we will rethink time and the relation of science to capitalism. Time is frequently compared to money: to make money on the stock market, one does not need to be smarter than the competition, just faster. To manage time and its effect on money, we will need to find new ways of gaining better control of both. How? By upsetting current hierarchies between the sciences and the humanities, and by relearning to appreciate the value of history.

Jimena Canales holds the Thomas M Siebel Chair in the History of Science at the University of Illinois. Her book, The Physicist and The Philosopher: Einstein, Bergson and the Debate That Changed Our Understanding of Time*, will be published by Princeton Press in 2015*

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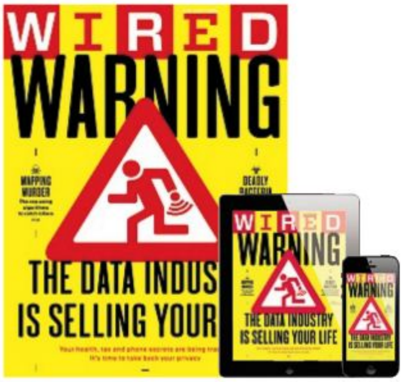

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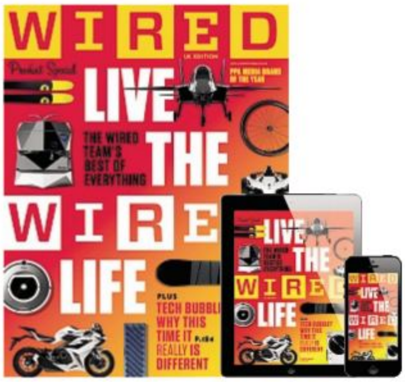

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MEDICINE

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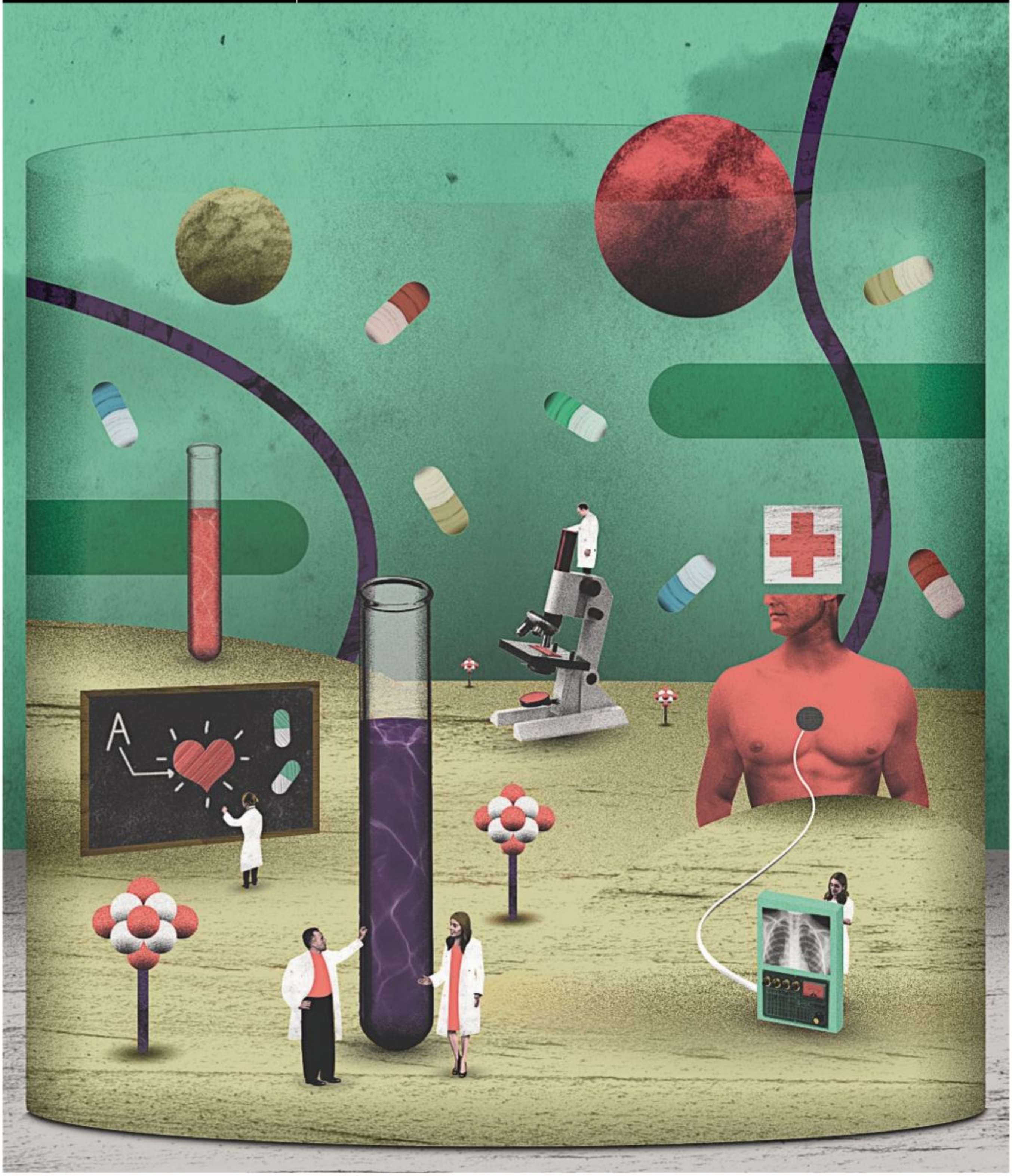


MACHINES WILL DIAGNOSE AND PREDICT OUR AILMENTS

The doctor/patient relationship is about to change as health services start investing in computer GPs

By **Hugh Montgomery**

COMPUTERS WILL BEGIN TO TAKE over a doctor's role in diagnosing ailments and predicting the chances of the patient recovering.

A good doctor exhibits compassion – but this never compensates for incompetence. Patients want a rapid, correct diagnosis and to know what the future holds. Good doctors deliver both precision and prescience by comparing the patient's story, symptoms, their own discoveries and test results with those in a mental database constructed through years of experience.

But there are limits. How do they differentiate between similar patterns of presentation for different diseases? For instance, a mild case of the 'flu may start with the same signs and symptoms as lethal meningococcal septicaemia. How do they predict an individual's chances of recovery? If 95 per cent of patients with a particular ailment die within nine months, who is in the five per cent? How can they reconcile the statistical "normal range" of test results with biological normality, which is different?

This will start to change in 2015 as big data takes over from human intuition. Health services across the world have invested heavily in computation that can mine their extensive historical data-sets. The UK's National Health Service alone holds data for tens of millions of people, comprising details such as age, race, gender, blood tests, birth complications and growth rates, height, weight and smoking habits, vaccinations and drug interventions, X-rays and scan results. All of these are linked to diagnoses and prognoses.

X-rays will no longer be interpreted by eye. Already, doctors at UCL's Institute of Neurology in London take computerised tomography brain scans of patients after suffering a stroke and let software predict what the damaged half of the brain should look like. It then lets voxels – 3D pixels – "vote" how different they are from "normal" brains. This doubles the doctors' ability to predict the chances of recovering from a stroke. From 2015, such systems will become automated. Computers will also automatically seek complex patterns in blood results in real time and in the digital waveform characteristics of electrocardiograms. And because every variable is compared and matched to diagnosis and the chances of recovery, the software is able to learn and improve over time.

In some cases, it already appears that computers can match the diagnostic skills of a human doctor. Within three years, computers will start to outperform them. Error-free prescriptions will be made by computer. There will no longer be futile attempts to prolong suffering in the hope that a life can be saved. Benign diagnoses, when reviewed and corrected by a computer will trigger life-saving intervention.

There is the risk that doctors might come to view themselves as just the human (inter)face for the computer-patient relationship. As a consequence, long-learned skills and wisdom will be lost. Many medical reasoning processes and observational skills have been handed down from the times of Galen and Hippocrates and are difficult to commit to paper or digital files. And many will rethink their roles within the profession. But software making diagnoses and predicting the nature of a patient's recovery are here – and doctors will have to change to accommodate them.

Hugh Montgomery is chair of intensive care medicine at University College London

HEADACHE RELIEF

-

A battery-free neurostimulator made by Autonomic Technologies in California has been implanted in a Ohio patient's cheekbone to block nerves near the nose when a headache comes on. Liat Clark

ILLUSTRATIONS BY **NATE KITCH**

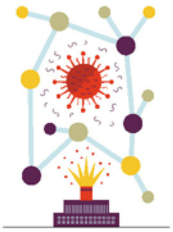
LOOK AT THE EYES

Cheap and affordable retina scanners will gauge the health of patients around the world

By **Ramesh Raskar** and **Karin Roesch**

THE RETINA IS THE ONE PART OF the body where blood vessels can be seen directly, so studying it can provide an extraordinary perspective on an individual's health status. In 2015, technologies will enable more accurate and less invasive diagnoses of conditions such as stroke, heart disease, hypertension and diabetes.

Changes in the width of retinal blood vessels or the presence of unusually branched vessels can reveal signs of vision-related diseases as well as systemic disease such as diabetes. Current applications focus on monitoring existing disease, with the eye considered a lagging indicator, but next-generation technology will enable health predictions via the eye. Tiny changes in retinal blood vessels will be tracked for warning signs of impending cardiovascular (heart) and cerebrovascular (stroke) events.



CANCER KILLER

Researchers at the University of Southampton have developed a synthetic molecule that binds to chloride ions in a cancer cell's membranes. This floods it with sodium, disrupting the ion balance and triggering cell death. This cell death differs from that instigated by cancer drugs, so could represent a new therapy. **LC**

For this to happen, the way we carry out retinal exams will have to change. Eye assessments currently rely on expensive high-definition imaging which has created a worldwide bottleneck and lack of access to eye exams. But new technologies being developed here at MIT Media Lab's Camera Culture Group will change this and allow millions of people to be tested quickly and cheaply.

The project, eyeMITRA, explores the eye as an indicator of a disease that may be stoppable by early treatment. Scans will be undertaken automatically on a portable, easy-to-use imaging device and the resulting images will be analysed by eyeMITRA's algorithms. In such a scenario, retinal imaging will be used as an "interval" sensor, meaning scans can be acquired repeatedly – on a daily basis, say – instead of through an annual screening. Frequent data capture will help to create meaningful baselines for each patient and will better inform what "normal" looks like. Subtle changes and variations will be detectable, which will reveal risk factors and allow patients to obtain a glimpse of any upcoming problems. Regular screening will also prompt preventative strategies and lifestyle adjustments.

In 2015, data collected from our eyes will help us calculate the odds of future health outcomes, where not only correlation, but also causality matters. The eyes will become a window into an individual's health, as well as the health of society around the world.

Ramesh Raskar is an associate professor of media arts and sciences at the MIT Media Lab and head of the lab's Camera Culture group. Karin Roesch is an entrepreneurial scientist at the lab. Neither has any commercial involvement with this technology

SOFTENING THE HEART ATTACK

A Cambridge team has discovered how to soften a cardiac arrest's potentially fatal side effects

By **Hank Campbell**

SPOT ILLUSTRATIONS: JAMIE JONES

TISSUE DAMAGE CAUSED BY HEART attacks can cause long-lasting ill effect. But thanks to a University of Cambridge research team, it may be reduced.

In the UK alone, more than 100,000 people die from heart attacks each year, but in many cases victims who are successfully treated suffer from ischaemia, the progressive ripple effects of heart attacks and stroke, even after a successful resuscitation.

When the heart resumes working, the sudden influx of oxygen-rich blood damages cardiac tissue. This damage, caused by the blood starting to flow again, is called reperfusion injury. Its key driver appears to be mitochondria, our cells' energy factories that use oxidisation to convert food into fuel. During a heart attack, that oxidation process gets backed up because the lack of blood means there is no oxygen to carry away the electrons created in the mitochondrial process.

Now a research team led by Michael Murphy of the Medical Research Council Mitochondrial Biology Unit at the University of Cambridge has developed a compound that can flick a switch in mitochondria, causing them to "meter out" oxygen influx so that damage caused by generation of mitochondrial reactive oxygen species in body tissue is prevented.

During a heart attack, tissue can be deprived of oxygen and glucose for up to 30 minutes before blood arrives again. The rush of pro-oxidants in new blood overwhelms and damages DNA, proteins and lipids, and that has an impact on the patient's future health. Murphy and his team have developed a new compound called MitoSNO which delivers nitric oxide to damaged tissue and fends off that mitochondrial energy crisis.

"It's a catch-22," says Murphy. "After the heart has stopped and organs aren't receiving blood, you have to put the blood back in, but in doing so you get a whole bunch of damage. You recover from the heart attack or stroke but the damage to the tissue, muscle and neurons is then caused during those few seconds of the oxygen coming back into the suffocating tissue."

MitoSNO can be administered intravenously and immediately reduces tissue necrosis when the heart reboots by slowing down mitochondria activity for a few minutes. This stops the cells from releasing the free radicals that cause the damage. In the Cambridge studies, the compound significantly reduced damage after a heart attack. After that, the patients' bodies gradually took over and restored reduction and oxidation balance after the cellular crisis had passed.

Hank Campbell is the founder of science journal Science 2.0, science20.com

LAB VISION

–

Retinas with cells that respond to light, grown from human-induced stem cells, have been engineered at Johns Hopkins School of Medicine, Maryland. LC

BLOOD SHORTAGE

Half of all blood donations come from wealthy countries, home to just 20 per cent of the world's population; refrigerated supplies last only 35 days. The Haem02 project at the University of Essex has received £1.5 million to develop synthetic blood. Made from a haemoglobin-based oxygen carrier, Haem02 has discovered a way to detoxify the iron and free radicals the blood produces. It lasts two years at room temperature. **LC**

THE DOCTOR INSIDE

Embedded nanosensors will start to monitor and treat our health – without the need for surgery

By **Thomas Webster**

A BIG CHALLENGE FACING INVASIVE surgical procedures, such as hip replacements or the insertion of vascular stents into arteries, is how to monitor their performance after the patient has been stitched up. Often, diagnostic tools such as MRI or X-rays cannot detect bacteria and resulting scar tissue until it is too late to treat. At this stage the implant has to be removed and a new one inserted – an invasive process requiring long-term rehabilitation.

From 2015 internal nanosensors, developed by my team at Northeastern University, will be able to monitor and treat a build-up of bacteria before it can cause damage. These will have applications not only for post-surgery monitoring but will also allow the internal monitoring and treatment of cardiac problems, cancer, diabetes, arthritis, infection and other ailments.

The sensors are essentially nano-size electrical circuits that can identify bacteria, blood components, cellular mutations, bone-density loss and, if necessary, can apply treatment. Because of their size, they can probe tissues and cells, collecting information and making real-time diagnoses. If they detect a problem they can communicate with a smartphone and report if an ailment has been sensed. In the event that sensors themselves cannot treat the ailment, they will provide detailed information for clinical intervention at a much earlier time than if traditional methods were used.

Although these nanosensors can be placed directly into the body to gather data, their clinical application in 2015 will centre primarily around their incorporation into traditional implants, such as artificial hips or vascular stents. If the sensors pick up anything untoward, they can be programmed through a handheld device to release a drug to kill bacteria or reduce scar-tissue growth so that bone can grow healthily next to the implant. By releasing drugs, or in some cases by releasing a small voltage at the site, healthy-cell toxicity can be avoided and a more effective treatment can result. The same approach can be used to monitor the state of vascular stents. Most are made of metal and can induce an inflammatory response and cause the artery to clog again. Sensors can be placed on the stents to report back if tissue growth occurs and to release a drug that makes clots decompose.

These are early days for internal nanosensors, but the concept has a lot of potential. In the longer-term future, the technique could be used to treat cancerous cells. A tumour can be treated more effectively with minimal toxic side effects if a chemotherapeutic drug is released next to or inside the cell.

We are entering a new era of personalised medicine, in which we can detect changes in biological functions and fix them before they lead to complications.

Thomas Webster is professor of bioengineering at Northeastern University

SETTING THE PACE

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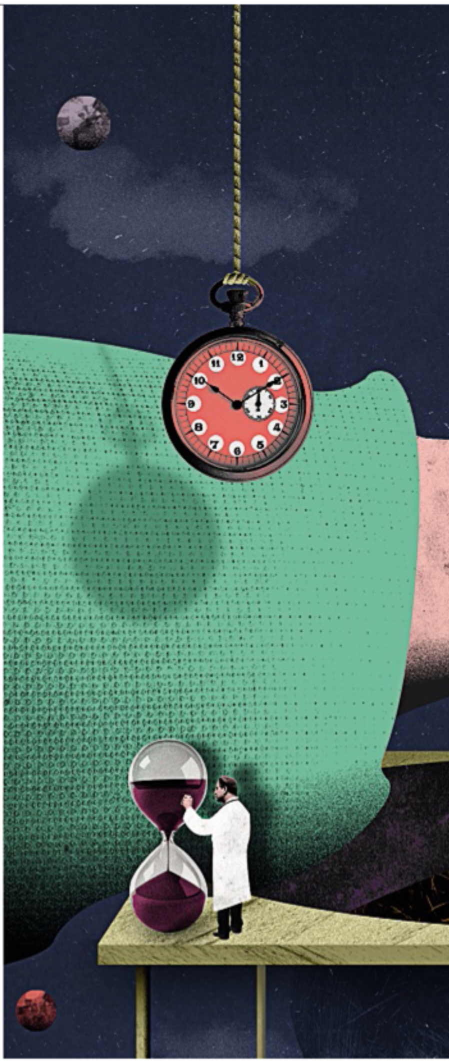
A team from Korea Advanced Institute of Science and Technology has proven its pacemaker, a flexible semiconductor film, can harness enough energy from a rat's movement to stimulate its heart. LC



THE RETURN OF DEEP SLEEP

We will wake up to the huge importance of slumber for our mental and physical wellbeing

By **Russell G Foster**

SLEEP REMAINS THE BEST AND MOST effective way to enhance our cognitive abilities and health. In 2015, we will recognise that the way we have downgraded it is dangerous.

Throughout the 20th century, humans in the developed world abandoned sleep. Thomas Edison introduced commercially viable incandescent light bulbs in 1879; by the time artificial lighting proliferated 50 years later, our work and leisure time had been transformed. Today, extended working hours, long commutes, 24-hour social media, distractions from multiple electronic devices and the alerting effects of light on the brain's arousal systems all conspire to distort our ability to experience sufficient biological sleep. In an attempt to cope with tiredness, many individuals have fallen into a stimulant/sedation feedback loop whereby stimulants such as caffeine and nicotine perk us up during the day; at night, sedatives such as alcohol and sleeping pills are used to calm us back down again.

Research tells us that a huge amount of essential physiology occurs during slumber. The pathways linked to carbohydrate metabolism, "stress" hormone release and inflammatory and immune responses are all rebuilt during sleep. It is also critical for memory consolidation and information-processing by the brain. We have all benefited from sleeping on a problem. Disrupted sleep, by contrast, contributes to a broad range of interconnected health problems such as type-2 diabetes, reduced immunity, poor decision-making, anxiety and depression.

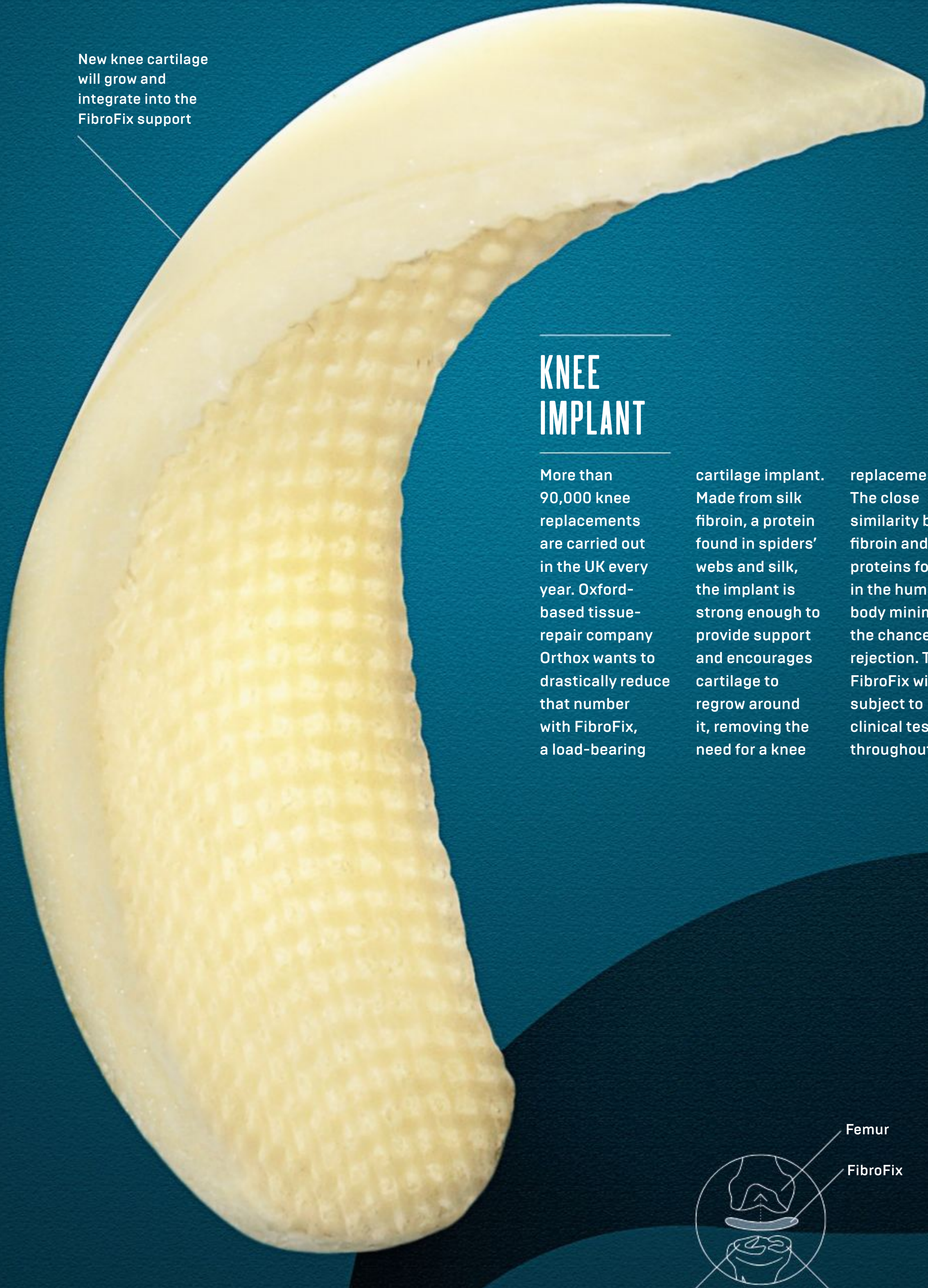
In 2015 there will be widespread recognition that sleep is the best health and cognitive enhancer available. In the UK, funds from the Wellcome Trust, the Sir Jules Thorn Charitable Trust and Oxford University will enable the launch of the first institute dedicated to understanding the fundamental neuroscience of sleep. It will raise awareness about the importance of sleep and initiate several major studies – for example, the impact of a later school start time will be assessed on the health and educational performance in large numbers of teenagers. A major survey will define sleep disruption in individuals with eye diseases, correlating their severity with an individual's ability to align their sleep to the natural cycle of light and dark. Another study will investigate sleep in patients with bipolar disorder and schizophrenia.

In the commercial sector we will begin to see new devices to measure sleep and its related behaviours. Plenty of apps and sensors are available which are supposed to measure sleep, but few have been rigorously validated and some may even be misleading. But companies such as Jawbone, Philips and Apple are working closely with sleep researchers to ensure that the next generation of devices provide accurate and robust measures of sleep. And these will not only tell us about our sleep, but also give us an excellent metric of our physical and mental health.

Russell G Foster is professor of circadian neuroscience at the University of Oxford

SUPERBUG SPREAD

Ongoing research could make superbugs a thing of the past. A team at Queen's University, Belfast, is testing an antibacterial gel that breaks the bacterium's biofilm coating, one of its key defences. Microbiologists have isolated a fungus molecule that, when combined with antibiotics, disables the bacteria. And a Lund University team is exploring antibacterial effects of 13 lactic-acid bacteria from bees' stomachs. LC



New knee cartilage will grow and integrate into the FibroFix support

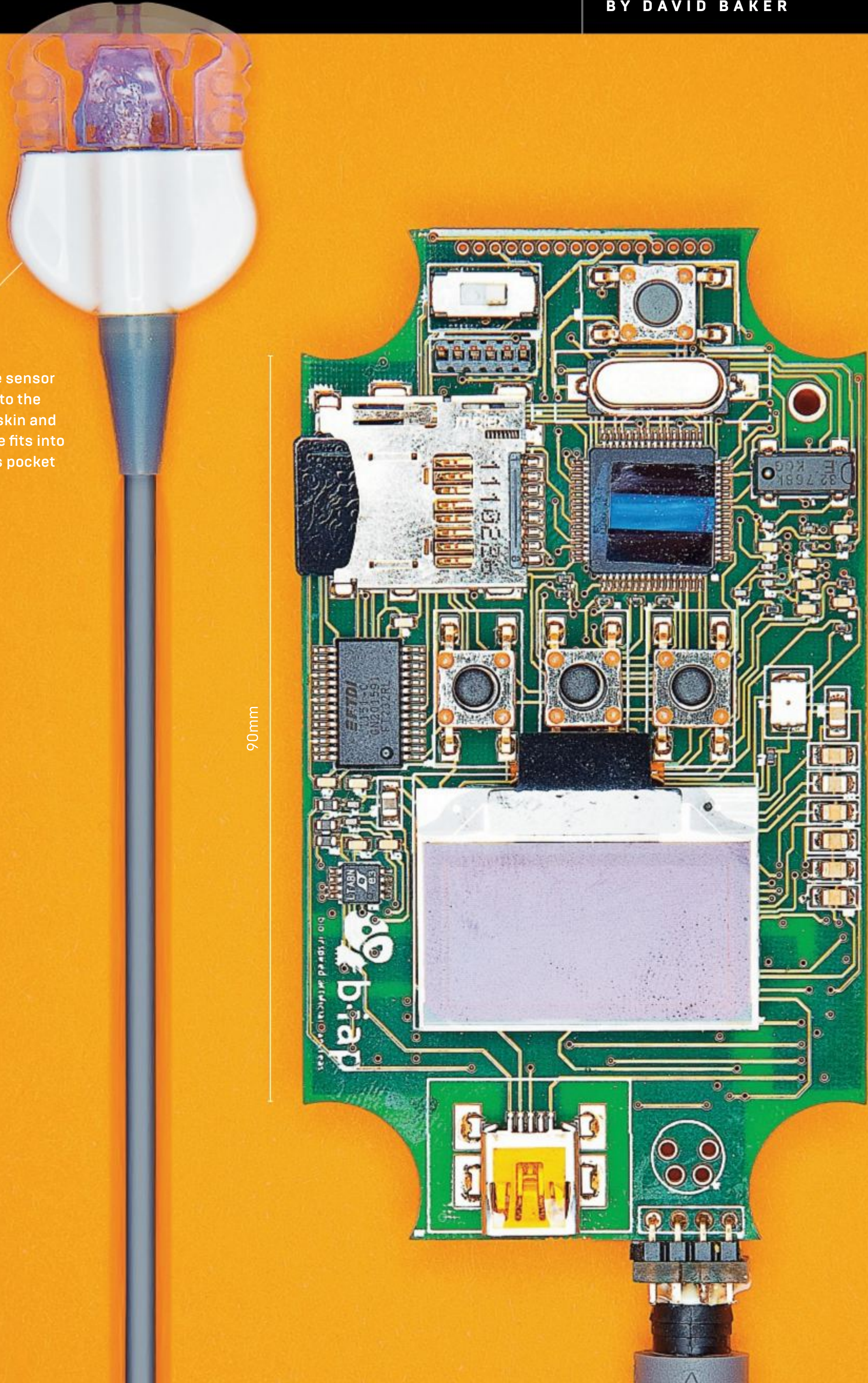
KNEE IMPLANT

More than 90,000 knee replacements are carried out in the UK every year. Oxford-based tissue-repair company Orthox wants to drastically reduce that number with FibroFix, a load-bearing cartilage implant. Made from silk fibroin, a protein found in spiders' webs and silk, the implant is strong enough to provide support and encourages cartilage to regrow around it, removing the need for a knee replacement. The close similarity between fibroin and proteins found in the human body minimises the chance of rejection. The FibroFix will be subject to clinical testing throughout 2015.

MEDICAL TECH

SIX HEALTHCARE DEVICES FOR 2015

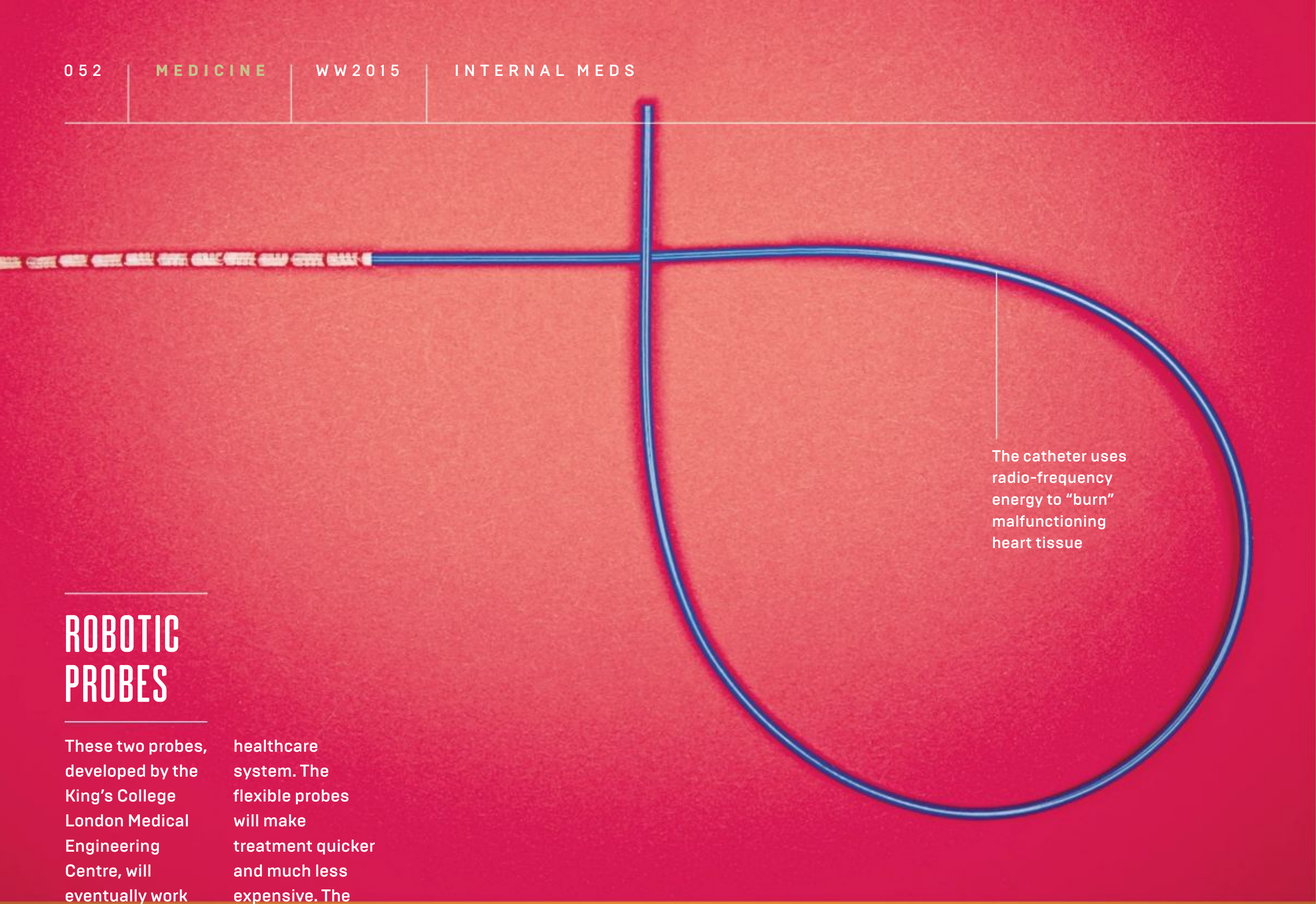
BY DAVID BAKER



A glucose sensor attaches to the wearer's skin and the device fits into the user's pocket

ARTIFICIAL PANCREAS

People with Type 1 diabetes have to monitor their glucose levels regularly and inject themselves with insulin. But inexact dosage, phobia of needles and insulin resistance can reduce its effectiveness and complications can include blindness, kidney failure, heart disease and stroke. This pancreas-on-a-chip, developed by a team at Imperial College London, monitors glucose levels in real time and delivers insulin as often as every five minutes. Clinical trials will continue in 2015.



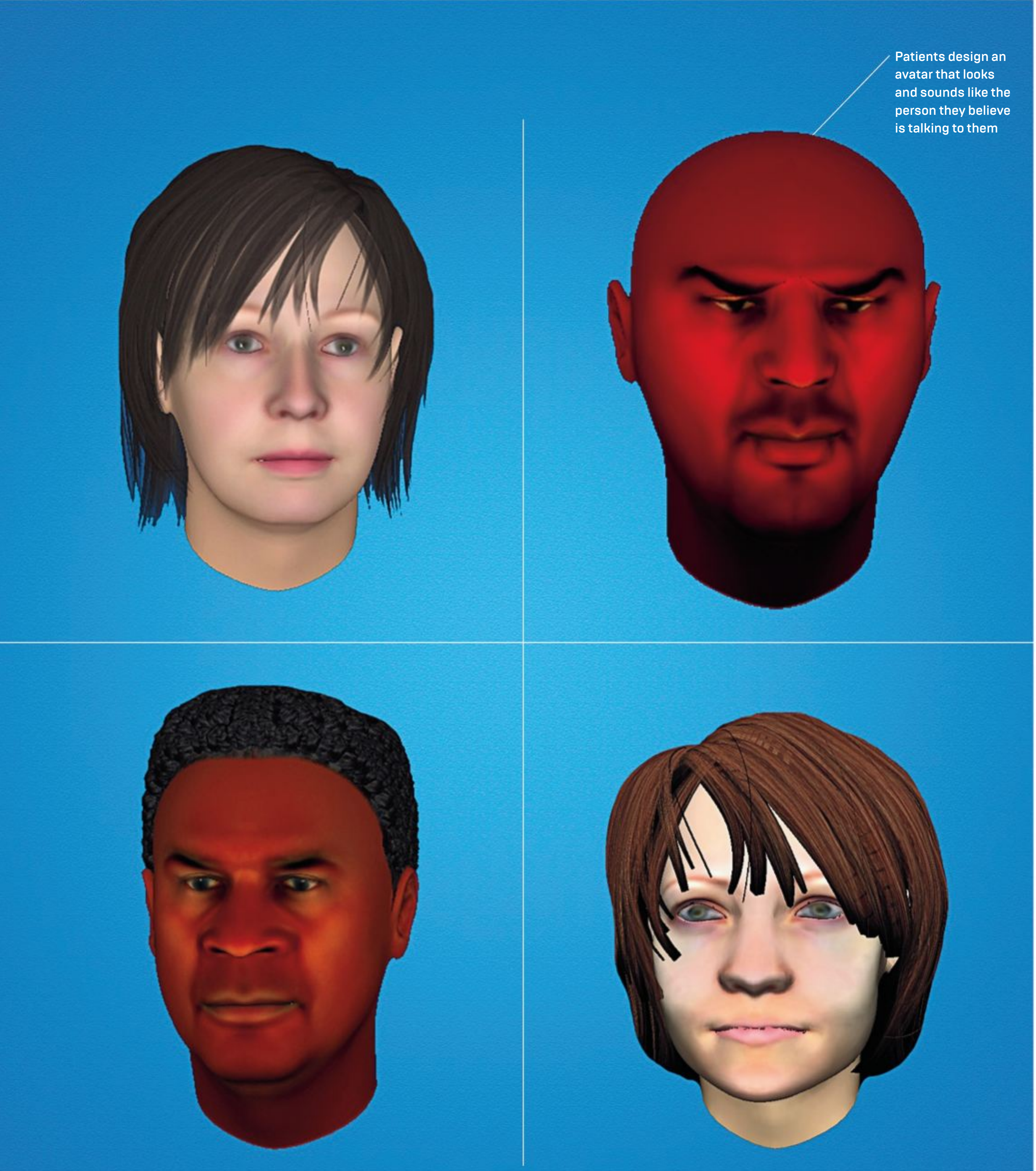
The catheter uses radio-frequency energy to “burn” malfunctioning heart tissue

ROBOTIC PROBES

These two probes, developed by the King’s College London Medical Engineering Centre, will eventually work together to treat arrhythmia, or irregular heartbeat. This common condition – it affects more than one million people in the UK every year – can be fatal and is a significant burden on the healthcare system. The flexible probes will make treatment quicker and much less expensive. The first (*above*) is inserted into the heart via a blood vessel where it can destroy misfiring tissue. The other (*below*) is fitted with an ultrasound sensor that passes down the oesophagus to give the surgeon a high-resolution view of the catheter and the heart itself. In-human trials will begin in 2015.

The probe and catheter will ultimately be able to work together autonomously

PHOTOGRAPHY: **CHARLIE SURBEY**



Patients design an avatar that looks and sounds like the person they believe is talking to them

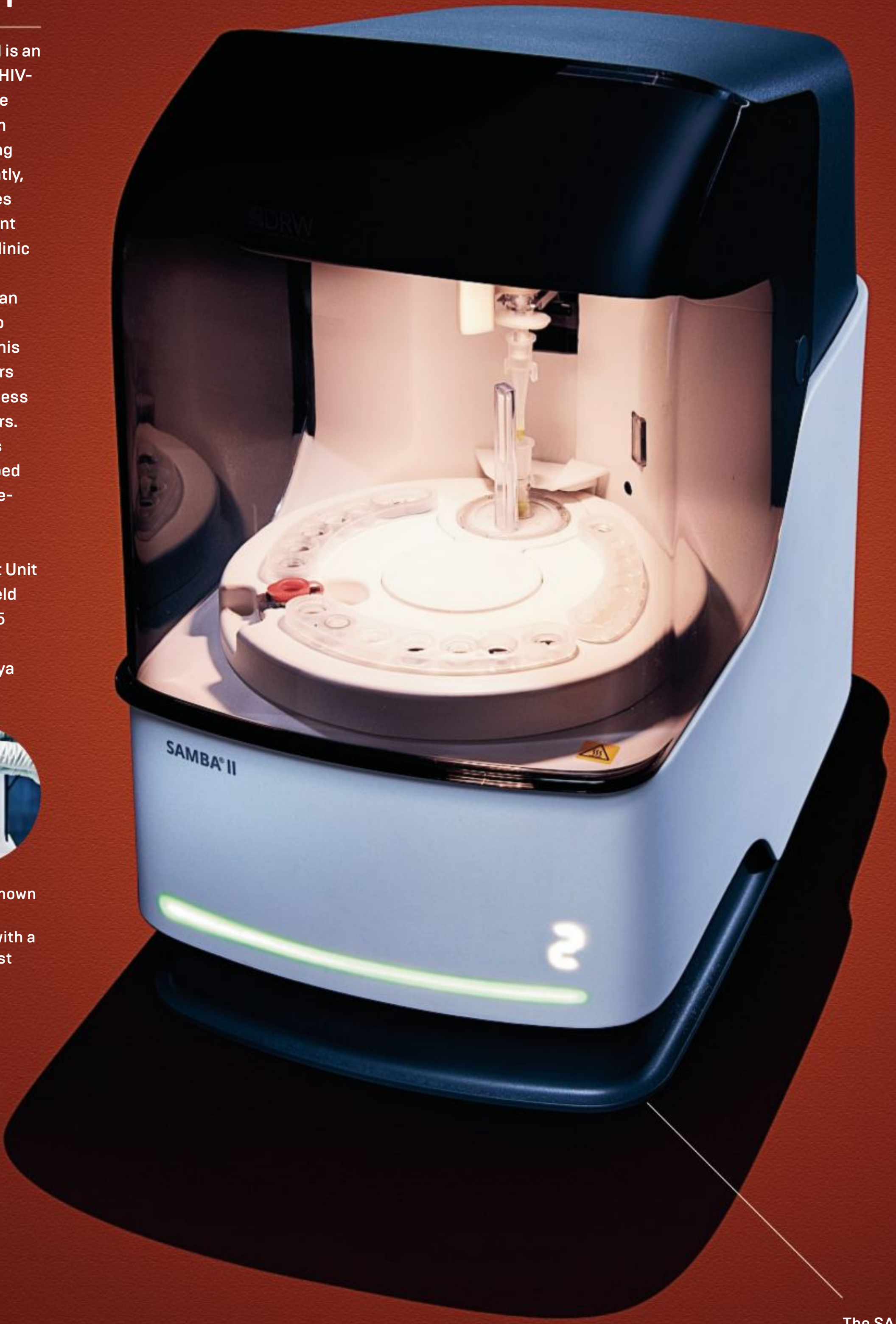
AVATAR THERAPY

Many people with schizophrenia hear distressing voices in their head. The avatars pictured above, developed by teams at University College and King's College London, allow patients to externalise the characters they believe are speaking to them and have a dialogue with them. A therapist speaks through the avatar and the patient is able to perceive the voice as less threatening. Early trials involving 16 patients have had positive results and in 2015 the therapy will be made available to a wider group.

INSTANT HIV TEST

The SAMBA II is an easy-to-use HIV-testing device for patients in the developing world. Currently, blood samples have to be sent to a central clinic for analysis and results can take weeks to come back; this device delivers diagnosis in less than two hours. SAMBA II has been developed by Cambridge-University's Diagnostics Development Unit and will be field tested in 2015 in Zimbabwe, Uganda, Kenya and Malawi.

Results are shown by a simple blue line, as with a pregnancy test



The SAMBA II measures 30cm (w) x 40cm (d) x 50cm (h) and weighs just 9.9kg

IMAGE: CORBIS. RESEARCH AND DEVELOPMENT OF EACH OF THESE PROJECTS IS SUPPORTED BY THE WELLCOME TRUST

Stem cells are directed into becoming red blood cells through biochemical cues in the laboratory

MAN-MADE CELLS

Ninety million red-blood-cell transfusions take place each year, but supplies are scarce. Blood cells manufactured artificially using human stem cells (*pictured*) could solve the problem. The cells can be produced in any blood type and will be stronger than the transfused cells. In 2015, a consortium of UK universities and the English, Scottish and Irish blood-transfusion services will begin manufacture ready for clinical trials in 2016.

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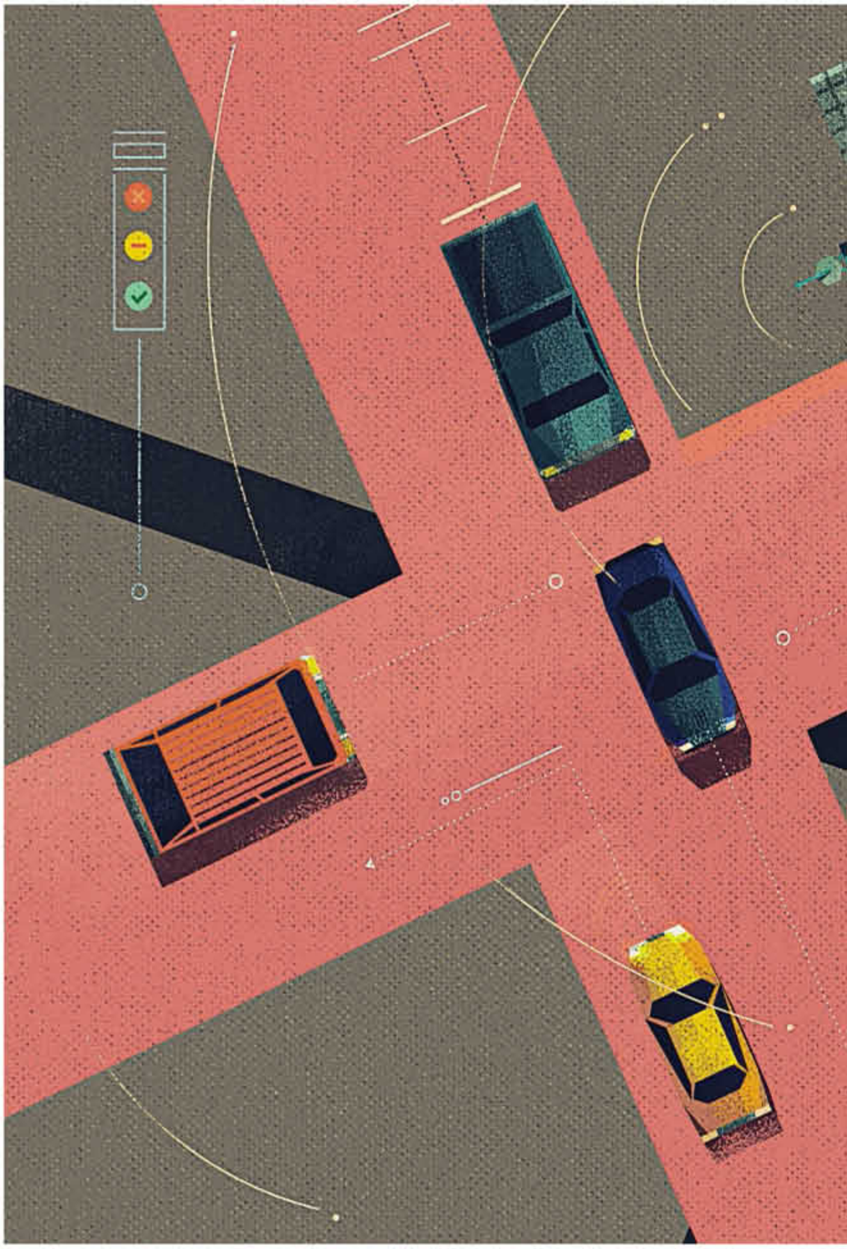
ENVIRONMENT

FEATURING WRITING BY

CARLO RATTI AND MATTHEW CLAUDEL, BEN HAMMERSLEY, MICHAEL HODGES AND JONATHAN GRABOWSKI



DRIVERLESS CITIES SPEED UP

Your car is on the cusp of driving you to work by itself – and as long as you don't mind sharing, it'll drive your neighbours, too

By **Carlo Ratti** and **Matthew Claudel**

OVER THE PAST DECADES, CARS HAVE slowly transformed from the kinds of mechanics Henry Ford might have imagined to computers on wheels. That change has brought a wave of digital innovations – chief among them, autonomous driving. Self-driving and -parking cars are already a reality, but in 2015 we will encounter something with a far greater impact: the driverless city.

Although the first autonomous cars date back to the late 20th century, recent increases in sophistication and reductions in cost of computing and sensing – such as cheap LiDAR (light detection and ranging) systems, which are able to "see" a street in 3D in a similar way to the human eye – have brought driverless cars to the road. In January 2015 the UK will allow the first driverless cars on public roads. By 2050, virtually all vehicles could be self driving, according to a 2014 IHS Automotive report prophetically titled "Autonomous Cars – Not If, But When". But what are the meaningful benefits of self-driving? Will autonomous cars have more of an impact than offering the luxury of reading a book, taking a nap or guiltlessly texting while on the move?

Far more interesting than the autonomous car is its scene and its system – the street itself. Self-driving vehicles will make a dramatic impact at the

EXERCISE ON YOUR SCREEN

Kids will be able to play on-screen games and exercise outside at the same time if Hybrid Play's system achieves its $160,000 Indiegogo funding target by 2015. The device, which comprises accelerometers, gyroscopes and IR sensors, wirelessly turns swings, slides and see-saws into games controllers that link via Bluetooth to another child's smartphone.

ILLUSTRATION: **DAN MATUTINA**

urban scale when they operate as a vehicle ecosystem, promising to blur the distinction between private and public modes of transportation. "Your" car could give you a lift to work in the morning and then, rather than idling in a parking lot, give a ride to someone else.

A paper by the MIT's SMART Future Urban Mobility team suggests that the mobility demands of a city such as Singapore – potentially host to the world's first publicly accessible fleet of self-driving cars – could be met with 30 per cent of its existing vehicles. Furthermore, other researchers in the same group suggest that this number could be cut by another 40 per cent if passengers traveling similar routes were willing to share a vehicle (proven through an analysis of New York taxi shareability networks). Picture it: a city where everyone can travel on demand, while removing four cars out of five.

Such operational efficiencies will start to be seen in 2015. In the long run, pervasive self-driving can dramatically cut the cost of mobility infrastructure and the embodied energy associated with building and maintaining it. Tomorrow's autonomous vehicles will prompt another wave of innovation, from road capacity optimisation to intersection management; autonomous fleets will slash travel time, congestion and environmental impact. Real-time data planning and smart routing will enable a more intelligent cohesive transportation network. Smart intersections are a key case study – algorithmically weaving traffic flows seamlessly without lights, as lanes "magically" pass through one another and avoid collision.

There are nonetheless obstacles to widespread adoption. To guarantee that our streets remain as safe – or safer – than they are today, various redundancies will have to be introduced to ensure that if one component fails, another automatically takes over. Although rarer, traffic accidents would still be a possibility, demanding a redefinition of insurance and liabilities (one that could fuel that great American pastime of suing for years to come). Finally, there is the fresh issue of digital security: we are all familiar with viruses crashing our computers... but what if the same virus crashes our cars? Although urgent, none of these issues are insurmountable. The race for a driverless city starts in 2015.

Carol Ratti and Matthew Claudel are, respectively, director and research fellow at MIT's SENSEable City Lab

POLITE SCANS

-

A graphene-based light detector, developed by the University of Maryland, will be able to detect hidden weapons on a person, without revealing details of their body surface.

SPOT ILLUSTRATIONS: JAMIE JONES

NEW TRADE ROUTES

China will still figure large in the production of goods – but the manner by which they reach western consumers will change

By **Ben Hammersley**

LANGUAGE MAY CHANGE, BUT roads tend to stay the same. In the centuries before the phrase "the Silk Road" brought thoughts of illicit Tor-network markets and swapping bitcoins for drugs and guns, the term would invoke the history of trade from China to Europe. Wagons from the east of China would carry spices, silk and supplies over 6,300 kilometres, across their country, through the deserts of central Asia, into Persia and eventually to the Black Sea, thence to Italy and the west. A route trodden since the third century, it linked China, India, Persia, Arabia and Europe. A source of treasures, tea and cultural exchange.

Today, China's main export isn't silk, but technology. As the slogan on the back of Apple products proudly puts it, "Designed by Apple in California, Assembled in China," your average phone, laptop, tablet or console is made there. But although Chinese factories are both cheaper and more versatile than those in the west, they are very far away. Your devices come to Europe by cargo ship: a trip that can take up to six weeks. That duration not only adds delay into the responsiveness of the just-in-time factories, but gives rise to the romantically pleasing idea that a Tim Cook keynote speech announcing the next iPhone, say, will happen when the devices are already halfway across the ocean, steaming towards us.

The next hot gadget won't arrive into Europe by ship, but instead by a re-opened Silk Road. Not by wagon train, but by a real train, on rails, through the Gobi Desert and the Russian steppe to Poland, in a trip taking just two weeks.

It's not just computer gear. Clothes and cars are travelling by rail from China too, as new routes are opening up. Earlier in 2014, delivery giant UPS announced the imminent opening of two cargo routes by rail from Chengdu, China, to Lodz, Poland, and from Zhengzhou, China, to Hamburg, Germany – both of which, UPS says, are twice as fast as shipping by sea, and 70 per cent cheaper than air freight.

That's not the end of the developments: China is busy upgrading its old steam-era tracks to take high speed rail (HSR). In 2006, China had no HSR track at all. Next year it will have more than 18,000km of it; by 2020, 21,000km. HSR track allows for the running of trains that today reach over 200kph, but they will soon go much faster, according to Zheng Changhong, chairman of CSR, China's biggest train manufacturer. An HSR freight track is being planned from China to Bulgaria, to be open by 2030, that will take heavy cargo at 160kph, and passengers much faster.

Perhaps the most audacious plans are yet to come. As well as a plan to lay high speed track down through Southeast Asia to Singapore, there is, according to a recent report in the *Beijing Times*, another Chinese plan to have an HSR line travelling north east, up through Russia, then underneath the Bering Strait in an unprecedented 200-kilometre tunnel – that's four times the length of the Channel Tunnel – over to North America. With a quick scoot through Alaska, into Canada and down into the continental US, the new tracks would eventually allow you to travel from London St Pancras International to Manhattan's Pennsylvania Station. There is no word, as yet, as to whether the Russians, Canadians, or Americans are, well, all aboard with the plan.

Ben Hammersley is a contributing editor to WIRED

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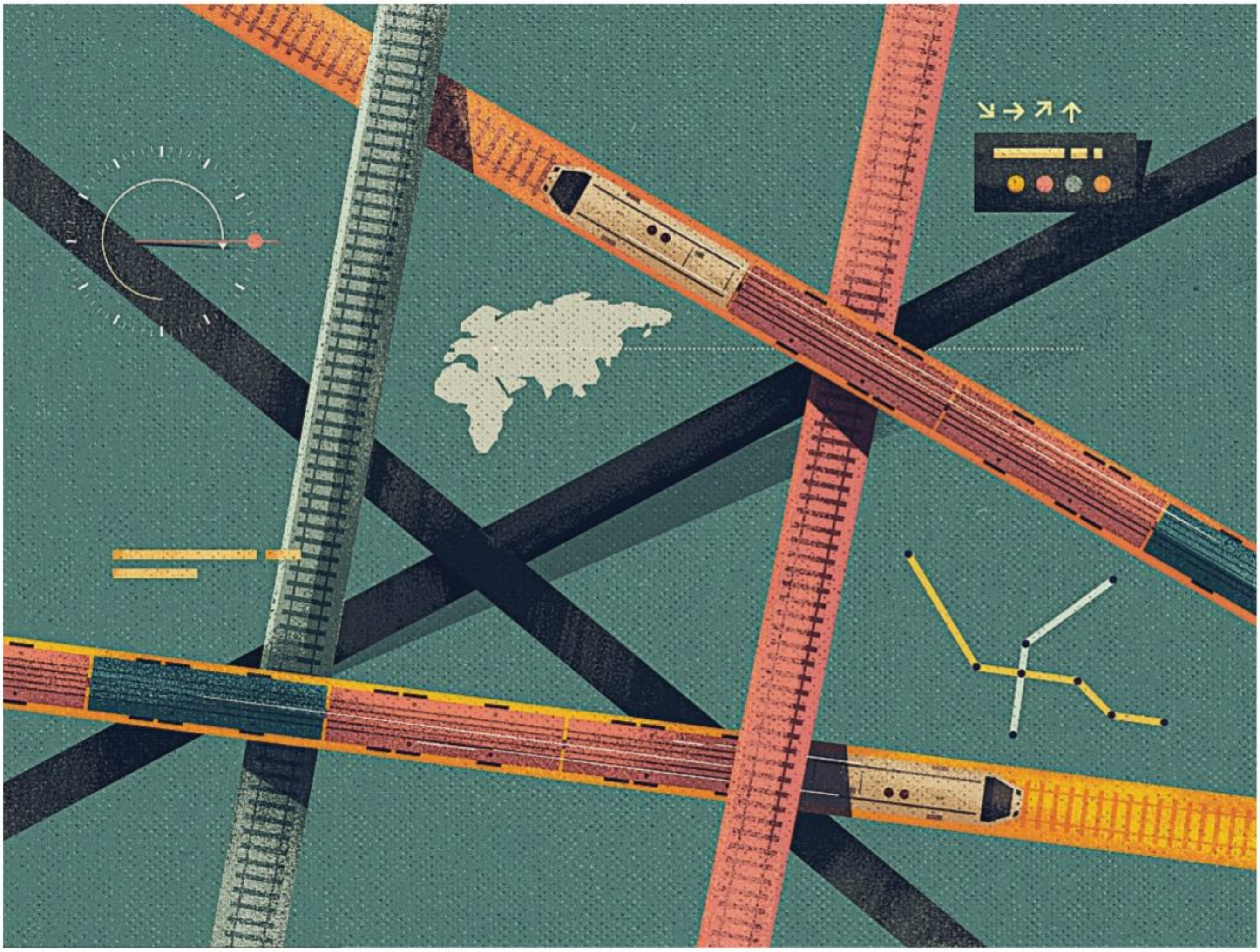
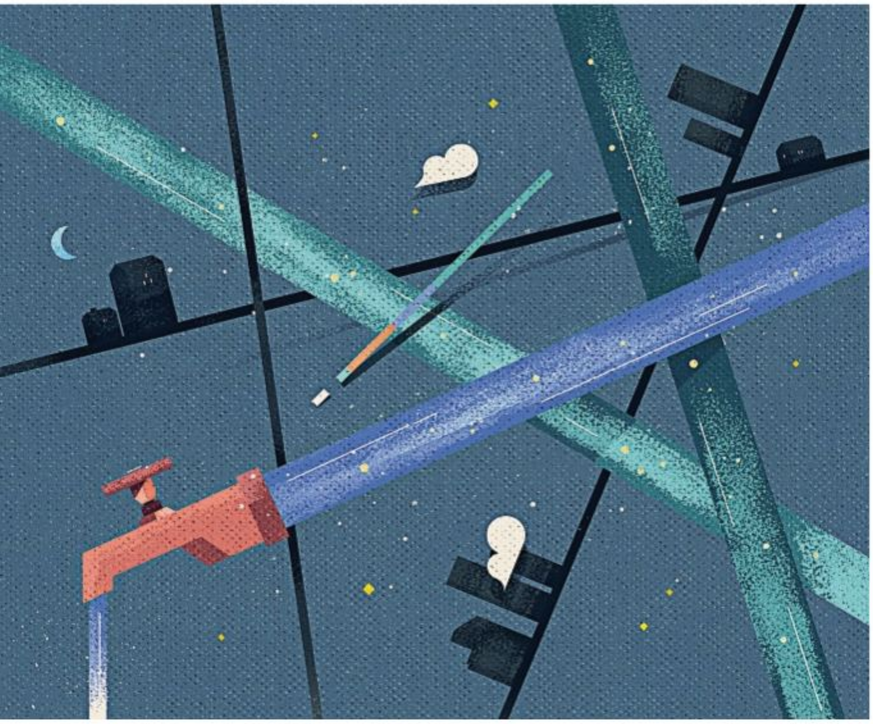
The size of each of the thousands of sensors in BAE Systems' spray-on skin for aircraft. It monitors factors such as airflow, temperature, hull strain and magnetic field strength in real time.





WE FINALLY TAKE WATER SERIOUSLY

Use and wastage will come under increased scrutiny in 2015, as we search for ways to satisfy our thirsts

By **Michael Hodges**

THE TIME HAS COME TO TAKE OUR wastewater seriously. "Wastewater is a resource," says Jacob Tompkins, managing director of Waterwise, a UK-based NGO that promotes the sustainable use of water. "Take our shower water, for example," he explains. "We heat it, put it on our skin for three seconds and then it goes down the drain. That's water and heat plus phosphates and some nitrates – all valuable commodities that we just chuck away."

In 2015, we will see far greater investment in in-home enclosed water systems, which are currently installed only in the greenest of residences. These will include components such as heat exchangers in shower trays and plumbing that collects rain from roofs, while "grey" water from washing and cleaning is used to flush toilets, all ensuring that as little water as possible ends up going down the drain. And the impetus for these will come from water-utility companies.

"If we all start installing homemade heat- and water-recycling systems, people could poison themselves," says Tompkins. "But I see water companies changing from companies that sell water to waste-service providers."

In the US, water utilities are already moving into this field. "Only three per cent of the drinking-quality water delivered to American homes is used for drinking," says Susan Story, CEO of American Water, the US's largest such utility. "The vast majority of it goes to watering lawns and gardens, washing clothes and dishes, bathing, flushing and other uses." But the US has experienced unprecedented droughts in 2014 and, Story says, water use needs to change. "When incidents that were historically considered to be '100-year' events happen more and more frequently," she says, "utilities must prepare for a new 'normal'." American Water now runs a water-recycling scheme over five high-rise blocks in New York's Battery Park, which it says saves 255 million litres of water a year. It has also developed a nitrogen- and phosphorus-removal process for wastewater treatment called NPXpress, which can reduce wastewater treatment costs by 50 per cent. And it is developing technology to monitor how its water-distribution network functions in real-time.

HYBRID AIR-DRIVE

Peugeot will be road-testing its Hybrid Air technology in a 1.2l family car – due to hit roads in 2016. The system uses compressed air instead of battery power to complement a standard petrol engine. Braking and deceleration recharge an air-tank that runs the length of the car. It provides zero-emissions power when the vehicle speeds up again.

"There are a million miles of water pipe in the US," says Story. "A major water main breaks every two minutes, and two trillion gallons of treated water are lost every year at a direct cost of about $2.6 billion [£1.6bn]."

Recycling wastewater will also be crucial to maintaining the US's agricultural sector. John Barsotti, president and founder of California-based Heron Innovators, which develops wastewater-filtration technologies, says that another drought would leave "more than 25 per cent of the farmland in the state's Central Valley fallow". Existing Dissolved Air Flotation (DAF) technology saturates used water with air under pressure. When the air is released in tanks, solids rise and gather on float cells where they can be skimmed off. However, much of the air is lost and up to 20 per cent of the dirty water must be recycled through the system.

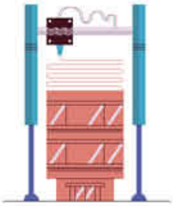
In response, the company has developed Suspended Air Flotation technology, which adds small quantities of surfactant to the wastewater to produce a foam stream that is about 50 per cent air. This removes more than 99 per cent of fats, oils and greases from water at a significant saving in energy costs.

Innovation is also taking place in the UK, though at a slower pace. In 2011 Thames Water opened a phosphate-recycling plant at Slough in Berkshire. In Birmingham the Accord Housing Association is pioneering a community scheme with Livingston-based firm Reaqua systems that filters and treats "grey" water from showers and baths then delivers it to toilets for flushing.

But these are small-scale schemes, and although the UK has certainly felt wetter than central California recently, Tompkins urges against national complacency.

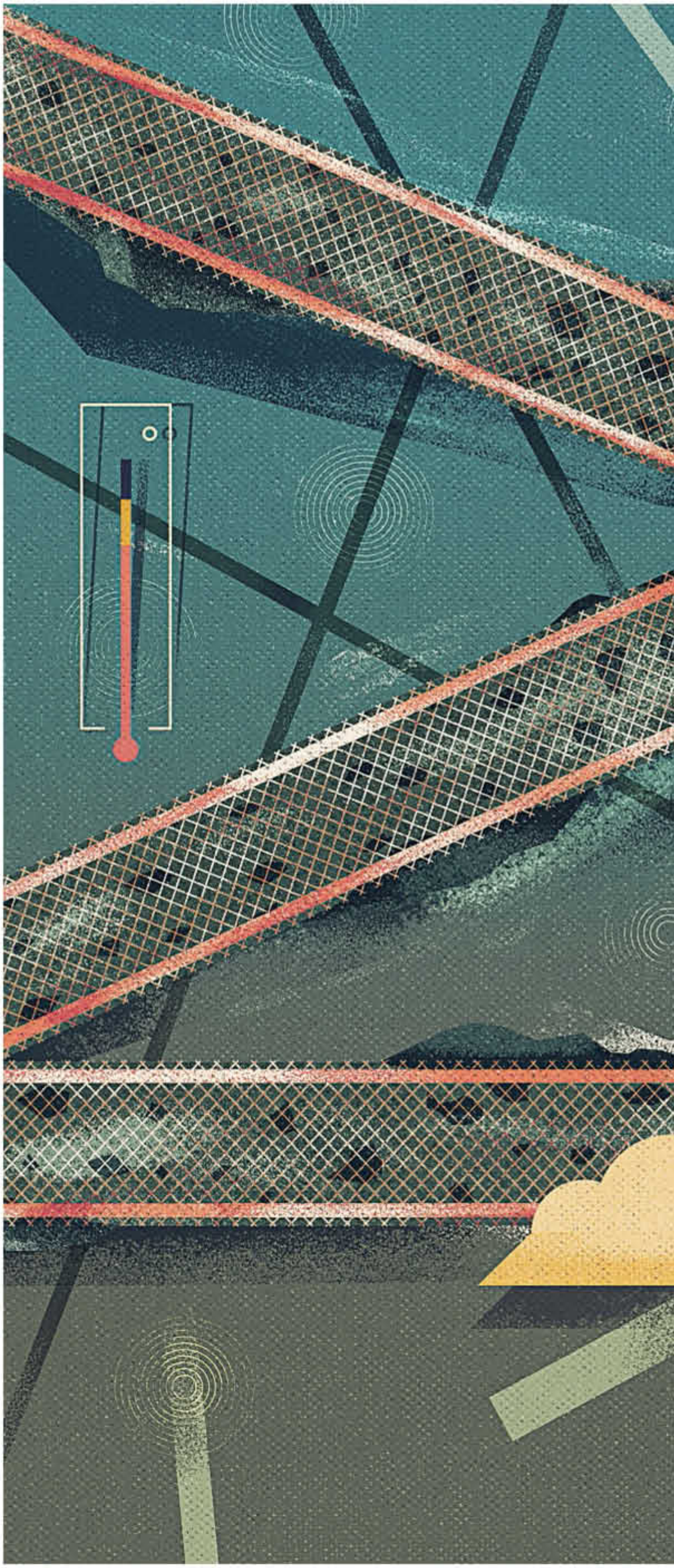
"Water is fast becoming one of our scarcest commodities," he says. "The [UK] drought in 2012 lead to discussions about using emergency measures for the Olympics which would have required approval by the Secretary of State. The only thing that stopped that drought was the highest rainfall in the UK for 100 years."

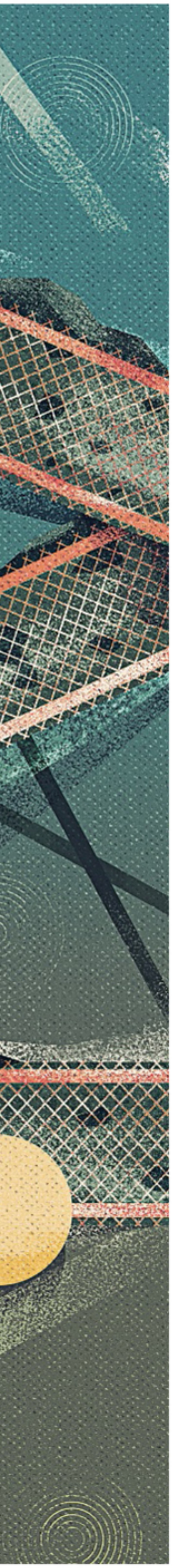
Michael Hodges wrote about the prospect of exploiting our national parks in The WIRED World in 2014



PRINTED BUILDINGS

New buildings 3D-printed on site could at last become possible, thanks to a mini-robot technology developed by the Institute for Advanced Architecture of Catalonia in Barcelona. Currently, buildings are printed in factories and assembled on site. The robots, which measure up to 42cm wide, come in teams of three, specialising in foundations, walls and strut-reinforcing. Once in situ, they work independently, co-ordinated by a central computer.





OYSTERS FIGHT CLIMATE CHANGE

An unexpected miniature hero will help save the planet in 2015

By **Jonathan Grabowski**

OYSTERS WILL BECOME HEROES in 2015, as oyster reefs become front-line troops in the battle to reduce the effect of human activity on the natural world. Oyster reefs are examples of important coastal ecosystems – the group also includes coral reefs, mangroves, salt marshes and sea grasses – that provide disproportionately high levels of ecosystem services. They support a wide diversity of species, enhance water quality, cycle nutrients, sequester carbon and stabilise our shorelines by reducing erosion.

Many of these critical estuarine habitats are highly imperilled by human activity. According to a report by US environmental organisation The Nature Conservancy, oyster reef habitats have already been reduced by 85 per cent globally and are particularly vulnerable because they are destructively harvested by oyster fisheries.

Now, led by the US, oyster reefs are starting to be rebuilt – and in 2015 they will become more biodiverse. Governmental and non-governmental agencies will be boosting oyster-reef restoration projects in 15 states, along the west coast of the US, in the Gulf of Mexico and across the eastern seaboard.

Restoration efforts will be aimed at ecosystems rather than small patches of habitat. The projects will involve ecologists, economists and social scientists working together to develop a quantitative framework that balances the return on investment from restoration and conservation efforts with associated costs. The focus will be on reefs that can provide the greatest socio-economic and environmental benefits. This will reduce environmental injustices. Disadvantaged people often live nearest to regions where habitat degradation and loss is highest, and coastal communities are particularly vulnerable to natural disasters such as hurricanes and flooding. In 2015, restoration efforts will be targeted towards the most endangered and impoverished coastal communities.

As humans modify the environment, a key question is which species will thrive and which will be pushed towards extinction. This question is particularly important for species such as oysters because they engineer habitats that are used by a vast array of other resident and transient fauna. Reefs provide refuge for other molluscs, crustaceans and juvenile fishes. Oysters are especially vulnerable to climate change as oceans become more acidic, and declines in oyster reefs affect these other species too. Early research suggested that oysters and bivalves in general are among those species most negatively impacted by ocean acidification. Yet my colleague Justin Ries and his team are beginning to disentangle the more subtle effects of acidification on these aquatic communities, such as how it influences predator behaviour and consumption of prey, and the results are more promising.

At the University of North Carolina, Tony Rodriguez and his colleagues have recently found that intertidal oyster reefs in North Carolina can grow far faster than previously thought, and are highly capable of keeping up with sea-level rises. Further collaboration among ecologists, ecosystem scientists and geoscientists will continue to advance our understanding of how oyster reefs and the communities they support can adapt to acidification and other environmental stresses. These will enhance reef-restoration efforts and help recover ecosystem services.

Jonathan Grabowski is associate professor, Marine Science Center, Northeastern University in Boston

RECHARGE

-

Power lines will be perches, if researchers at MIT can commercialise its bird-like drones that can draw energy from the lines' electromagnetic radiation when they sit on the cables.

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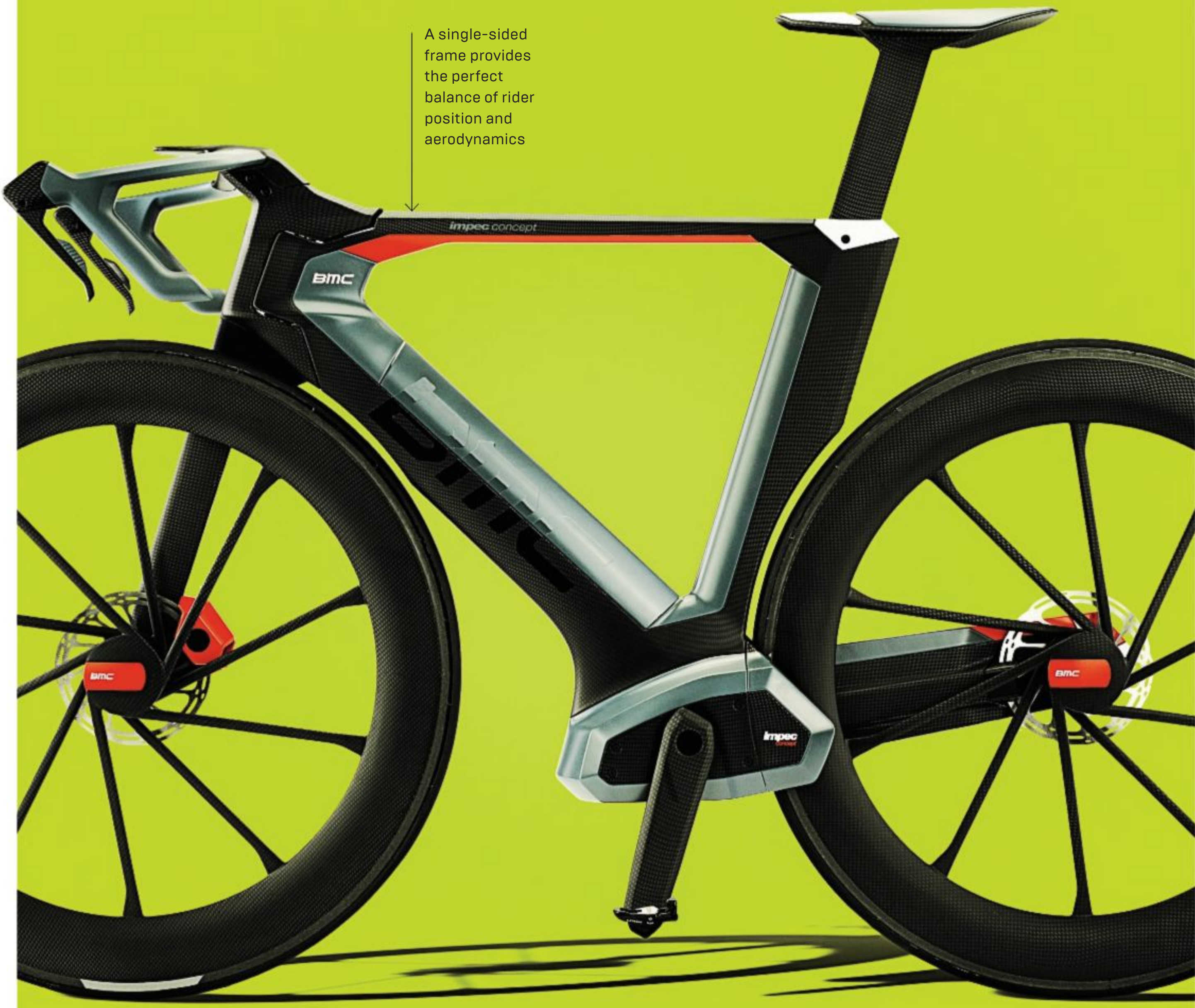
GEAR

EDITED BY **JEREMY WHITE**



A single-sided frame provides the perfect balance of rider position and aerodynamics

BMC IMPEC LAB CONCEPT BIKE

This radical racer from BMC's Advanced R&D Lab uses an interwoven carbon frame that's highly modular to suit each rider's cycling style. Its integrated gearbox lowers drag and adds more functionality than its rival sprinters. The twin-stem handlebar ensures absolute steering precision and minimal air resistance, and the shell and seat post are made from a single adjustable piece that is light but rigid. *Due mid-2015 €tbc impec-lab.com*

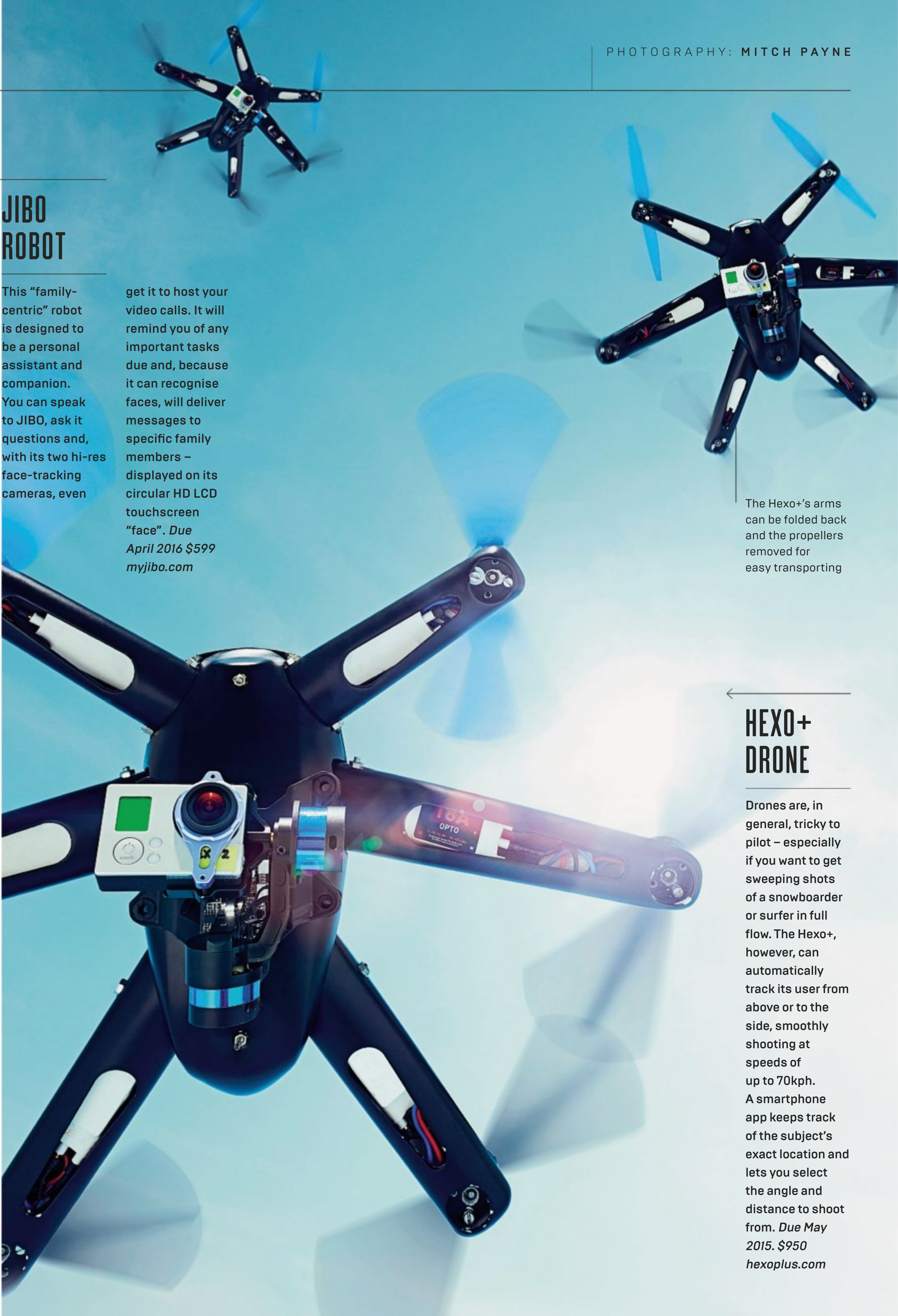
FETISH

Indiegogo funding for the JIBO shot past its $100,000 goal to more than $2.25 million

PHOTOGRAPHY: **MITCH PAYNE**

JIBO ROBOT

This "family-centric" robot is designed to be a personal assistant and companion. You can speak to JIBO, ask it questions and, with its two hi-res face-tracking cameras, even get it to host your video calls. It will remind you of any important tasks due and, because it can recognise faces, will deliver messages to specific family members – displayed on its circular HD LCD touchscreen "face". *Due April 2016 $599 myjibo.com*



The Hexo+'s arms can be folded back and the propellers removed for easy transporting

HEXO+ DRONE

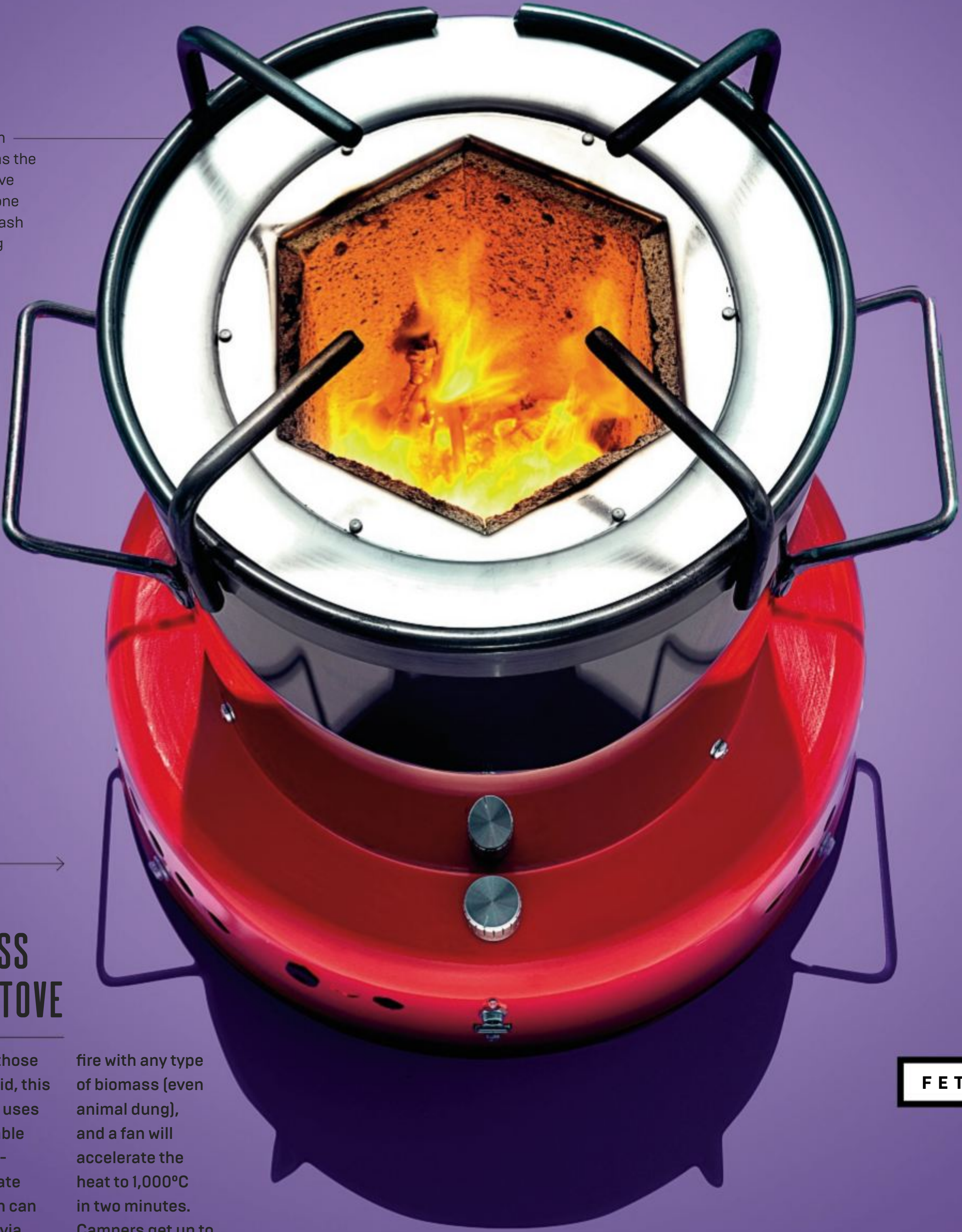
Drones are, in general, tricky to pilot – especially if you want to get sweeping shots of a snowboarder or surfer in full flow. The Hexo+, however, can automatically track its user from above or to the side, smoothly shooting at speeds of up to 70kph. A smartphone app keeps track of the subject's exact location and lets you select the angle and distance to shoot from. *Due May 2015. $950 hexoplus.com*

GOOGLE PROJECT ARA

The individual sections of Google's modular smartphones are held together by electro-permanent magnets and can be swapped out and upgraded as required. Google plans to release three sizes of phone: the basic Grey Phone that will cost as little as $50, plus a pair of higher-end units that could retail for up to $500. *Due early 2015 £tbc projectara.com*

You can swap out almost every Project Ara component, from camera to battery

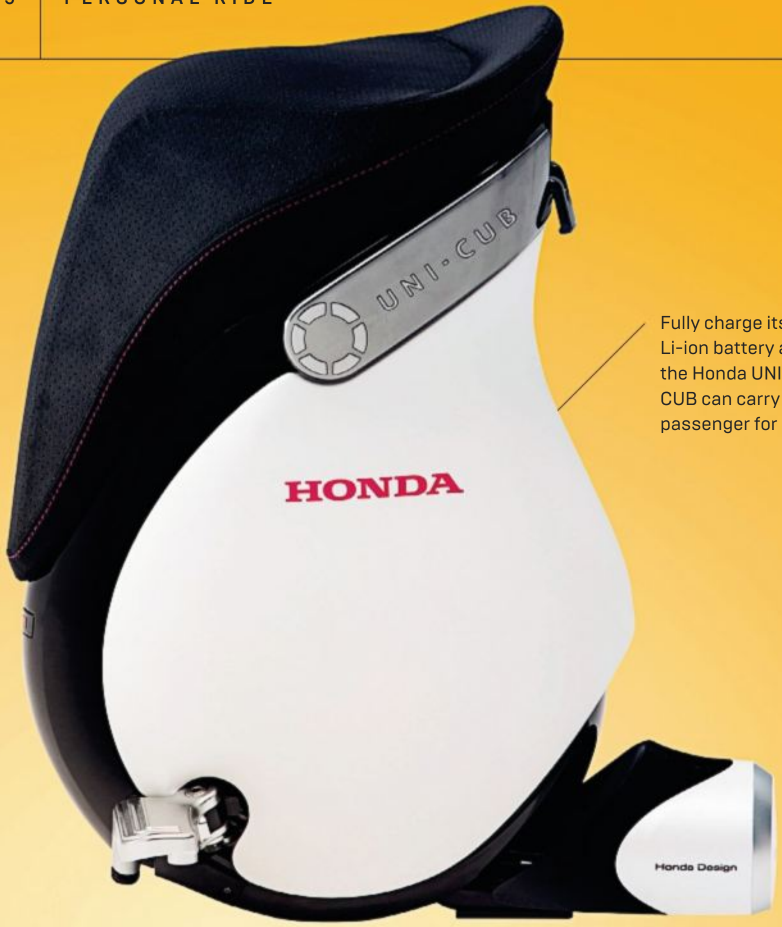
PHOTOGRAPHY: **MITCH PAYNE; MARK SERR**



African Clean Energy claims the ACE 1 will leave behind just one teaspoon of ash after cooking

ACE 1 BIOMASS COOKSTOVE

Perfect for those living off-grid, this 4.6kg stove uses a rechargeable 5Ah lithium-ion phosphate battery than can be charged via the mains or its built-in solar panel. Once charged, it lasts up to 20 hours. Create a small fire with any type of biomass (even animal dung), and a fan will accelerate the heat to 1,000°C in two minutes. Campers get up to 5kW of smokeless cooking that requires 70 per cent less fuel than regular stoves. ***Due January 2015 €159 africancleanenergy.com***



Fully charge its Li-ion battery and the Honda UNI-CUB can carry a passenger for 6km

HONDA UNI-CUB

No, it's not a robo-penguin, it's the latest iteration of Honda's personal-mobility devices designed for use in airports, museums, shopping malls and the like. The UNI-CUB's balance-control technology and omni-directional driving wheel system are ridiculously fun – just shift your bodyweight, lean in the direction you wish to travel and you're off. *European debut mid-2015 £tbc world.honda.com/uni-cub*

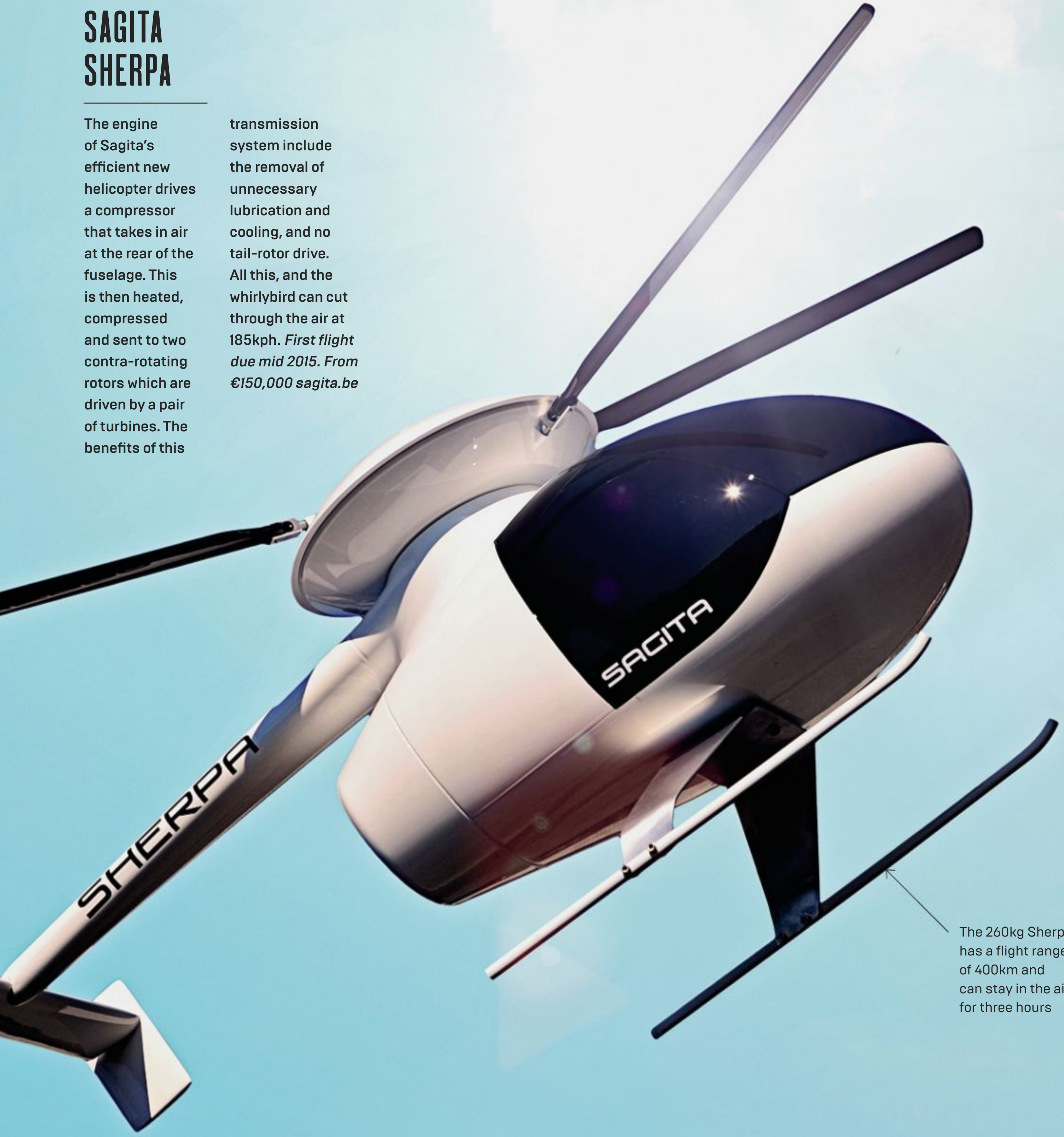
SPEC

Size 510mm (l) x 315mm (w) x 620mm (h)
Weight 25kg
Max speed 6kph

FETISH

SAGITA SHERPA

The engine of Sagita's efficient new helicopter drives a compressor that takes in air at the rear of the fuselage. This is then heated, compressed and sent to two contra-rotating rotors which are driven by a pair of turbines. The benefits of this transmission system include the removal of unnecessary lubrication and cooling, and no tail-rotor drive. All this, and the whirlybird can cut through the air at 185kph. *First flight due mid 2015. From €150,000 sagita.be*



The 260kg Sherpa has a flight range of 400km and can stay in the air for three hours

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WIRED Retail

November

London

Technology is shaking up how we buy, sell, receive and consume products. WIRED Retail will explore the huge changes taking place in this sector.

PHOTOGRAPHY: NICK WILSON

LIFESTYLE

FEATURING WRITING BY **LIOR FRENKEL, VICTOR J STRECHER, MARK MIODOWNIK AND DAVID HAMBLING**

EDUCATION SWITCHES ON

Online education platforms face a big problem: completion rates are low. In 2015 a global network of educators and students will usher in a new age in the quest for knowledge.

By **Lior Frenkel**

ONLINE EDUCATION PLATFORMS now allow anyone with an internet connection to enrol in more than 900 online courses offered by some of the best academic institutions in the world. Their purpose is to provide top-class, affordable education to all who seek it. In reality, however, students on these massive open online courses (MOOCs) have exhibited very poor completion rates. In 2015, owing to a specifically offline innovation, successful online education will finally materialise.

There are currently tens of millions of students enrolled on online courses, but completion rates usually range between five and ten per cent. Creative "solutions", such as quizzes, games, progress meters and badges such as those introduced by Udacity, the MOOC platform cofounded by Stanford professor Sebastian Thrun, have not significantly alleviated the situation.

In 2015 we will discover that better results will come from adding an offline component to online education. Coursera, the world's largest online-education platform, has already launched an offline network of "learning hubs" situated in dozens of cities across the globe. Students gather together to watch lectures, discuss the material and tackle assignments as a group. As a result, completion rates are over 30 per cent – edX has achieved similar results through its Offline Meetups project. This, however, is just the beginning.

"The new ed-tech needs new pedagogy," says Jacob Hecht, CEO and cofounder of Education Cities, which focuses on turning educational systems into a central growth instrument for the cities in which they exist. The organisation has developed a new approach to teaching – the Education Team Model – which is based on two principles: first, each student doubles up as a

ILLUSTRATION: MUTI

teacher. Each is encouraged to identify and build on their strengths. Second, each team works towards a shared, measurable goal. The teacher, in this model, functions as a coach. Their job is to help team members find their strong points, to facilitate co-operation and to find a balance between team members.

Education Cities' pilot programme launched in 2014 in collaboration with the Israeli Ministry of Education. It involved 15 groups of students between the ages of 13 and 18, from across Israel. Students enrolled in the Australian Open University's "Introduction to Astronomy" course and Georgia Institute of Technology's "Mobile Robots" course and studied according to the Education Team Model. Those with good English-language skills were responsible for translating material into the team's native language, those with good maths helped with formulas, and so on. Each class then competed against the others and a weekly progress chart was generated, in view of which the teams' learning strategies were adjusted and improved. The results were impressive: a group of Israeli high-school students achieved an 83 per cent completion rate while attending a university-level course taught in a non-native language.

Hecht, with entrepreneurs Tal Maimon, Roi Zikorel and Michael Shurp, is now establishing a network of MOOC hubs, to be maintained by practitioners of a novel "Moocster" profession. The Moocster's role is to found and train education teams according to Hecht's model. In 2015, the pilot will branch out into India, Bulgaria and Spain. Hubs will be set up in public spaces, such as libraries, and in workplaces.

"In 2015 we could establish a whole network of students and teachers," says Hech. "We're well on our way to building new strongholds of life-long learning."

Lior Frenkel is cofounder of The nuSchool, an Israeli education startup

IN-CAR ALARM

A consortium of European companies and research institutions, including the University of Manchester, will be road-testing HARKEN, an in-car system that monitors drivers for signs that they are falling asleep. Using a heart monitor in the seatbelt and sensors in the seat, it aims to detect if a driver is dozing off – and sounds an alarm.

FULL FLAVOUR/LOW FAT

Dieters will be able to enjoy richer-tasting cakes and pastries as researchers at Heriot-Watt and the University of Edinburgh commercialise proteins that can replace fats in baking.

THE SEARCH FOR PURPOSE BEGINS

We've mastered the Quantified Self, now it's time to ponder our existence. A new approach to life – and death – is on the horizon

By **Victor J Strecher**

A KEY SECTOR FOR INVESTMENT IN 2015 will be health and wellness – but not in the way some may expect. In the coming year, efforts to better quantify the self will be overshadowed by a new way to think about health. Rather than fixating on longevity and the avoidance of death, many of us will reverse course and focus on life – specifically, on a self-transcending purpose in life: a purpose that is bigger than ourselves.

We won't necessarily become more religious. Notions of a Rick Warren-style "purpose-driven life" that require a god are beneficial to some, but not all. In fact, many of our existentialist philosophers who exhorted the need for purpose were atheists. But as Simone de Beauvoir said about aging: "There is only one solution if old age is not to be an absurd parody of our former life, and that is to go on pursuing ends that give our existence meaning."

Recent research shows that those with a strong sense of purpose are less likely to develop Alzheimer's disease, depression, obesity and insomnia, less likely suffer heart attacks or strokes, and more likely to live longer.

We are ushering in new approaches to enhancing purpose in life: through affirmation of core values, consideration of one's mortality (as the Stoics did 2,000 years ago, and the Buddhists still do) and meditation. A recent study at the University of California found that meditation increased purpose in life, which in turn was associated with greater chromosome repair.

It works in the business world, too. Companies with a strong purpose have been found to provide an investment return of more than ten times that of the S&P 500. These "firms of endearment" are focused on revenue-transcending purpose and are loved by their employees, customers and networks.

The new way of thinking about health will usher in a new approach to wellness. If the Quantified Self simply enables the Quantified Selfish, we'll do little to improve our health. But if we use tech – apps, including the one my own team has developed, biometric devices, and other data – to find and pursue a self-transcending purpose in life, we may begin to lose our fear of death, and start living.

Victor J Strecher is professor and director for innovation and social entrepreneurship at the University of Michigan School of Public Health and the developer of the On Purpose *app*

SUPER BOWL

The end of cables and chargers will come a step nearer as Intel brings to market its wireless charging bowl. A success at 2014's Consumer Electronics Show, it recharges devices placed in it by induction. Researchers at London's Queen Mary College hope to commercialise a zinc-oxide nanomaterial that can convert sound into electric current – enough to charge a mobile phone.

3D KNITTING BEGINS TO CLICK

Just as the sewing machine brought clothes-making into the 20th-century home, a new generation of low-cost knitting tools is about to open up fashion

By **Mark Miodownik**

KNITTING WAS ONCE THE PRESERVE of grannies. Then it got adopted by hipsters, who made it cool for a while. Now it's gone high-tech and will become the next big thing in the maker world.

3D knitting, as the tech version is called, was inspired by the 3D-printing revolution and aspires to a similar goal: to be the one piece of manufacturing technology in everyone's home. It doesn't make objects, it makes clothes – and for this reason it has a big advantage over 3D printing because it has a much more obvious use. Everyone wears clothes – and we are constantly replacing and updating them because they wear out or become unfashionable. Another advantage over 3D printing is reusability. For the coarser knits at least, garments can be "unknitted" should you not like the way they make you look, or if you just get bored with them, leaving you with yarn to turn into something else.

Three-dimensional knitting machines are already available and growth is on the up. OpenKnit is one open-source example – it can be built from a kit and is part of a manufacturing ecosystem that includes a software interface and a digital hub to share designs. OpenKnit already has a large global community, developing the platform and iterating both the hardware and software. As with all successful open-source projects, this will grow and spawn new and unexpected versions in 2015.

Commercial 3D-knitting machines have been in operation for more than 20 years, but they are designed for established mass production. In contrast, the open-source knitting community will change the way clothes are designed and made, and create new forms of clothing – in particular by integrating different types of fibres into the knit, such as electrically conducting threads. By doing so, the technology is kick-starting an open-source approach to wearable technology – with embedded sensors and increased functionality – something that, commercially, has been slow to take off.

To understand the potential of home 3D-knitting machines, it's worth considering how the sewing machine, which was introduced in the 19th century, completely changed the way that clothes were designed, made and repaired. Once it became sufficiently cheap it spawned a huge number of home businesses. These drastically cut the price of clothing and created innovations in fashion and garment making. Eventually, small businesses such as these gave way to the mass-produced-clothes manufacturers that dominate today's markets. Now the 3D-knitting machine promises another wave of disruption.

Every one of us is a different shape and size, and 3D knitting offers something the commercial clothes manufacturers cannot: inexpensive bespoke garments designed to fit you and you alone. This is achieved with the aid of digital scanning technologies and design software that can resize clothing designs to fit individual bodies. And because these garments can be made in the home, you can immediately try them on, and if they don't feel right or don't suit you they can be unmade there, too. Add to that the power of social media, which allows patterns and designs to be shared much more easily and readily, and the potential of 3D knitting technology becomes clear.

If I had to bet which machine, a 3D printer or a 3D knitter, would end up as staple technology in every home in ten years' time, I would go for the knitting machine. Humans have been making clothes at home for thousands of years – this just happens to be the latest way to do it.

Mark Miodownik is professor of materials and society at University College, London, and director of the UCL Institute of Making

FOOD SAFETY

Researchers at the University of Southampton will be testing a Listeria-detection device for kitchens. The bacterium is typically identified only after sending samples to a lab; the sensor uses an antibody that fluoresces in the presence of the bacteria. The glow is picked up by an in-built camera. The device works by differentiating live bacteria and harmless dead cells, common on kitchen surfaces.

DRONES IN THE WRONG HANDS

We've all seen kooky news items featuring beer-delivering UAVs. In 2015, we will be more concerned about criminals taking advantage of their availability, affordable price and ease of use

By **David Hambling**

UNMANNED AIRCRAFT ARE branching out into a bewildering variety of new roles, from providing broadband to delivering pizza. But in 2015, one sector is set for a drone bonanza: criminals.

The Phantom 2 drone is marketed as "your tripod in the sky", giving anyone a bird's eye view. Paparazzi will be using them to gain unlawful access to their victims. A photo-drone gatecrashed Tina Turner's wedding in Switzerland; Miley Cyrus posted an *Instagram* picture of one hovering over her home in July. There will be increasing numbers of celeb-stalking drone incidents in 2015 as new models with stabilised camera mounts produce pin-sharp, lucrative, illegal snaps.

It won't just be celebrities: a woman sunbathing on Virginia Beach reported being harassed by a drone operated by two creepy men. Drone hobbyist Austin Haughwout was assaulted on a Connecticut beach after someone mistakenly thought he was taking pictures of sunbathers in bikinis. Drone-related stalking and assaults such as these will multiply.

Last June, Lisa Pleiss phoned Seattle police when she spotted a drone hovering outside the window of her 26th-floor apartment. It turned out that the UAV was not watching her changing, as she suspected, but taking skyline pictures for a property developer. In 2015, we will learn to close the blinds, wherever we are.

Drone smuggling is also taking off. In 2009, CCTV at HM Prison Elmley in Sheerness, Kent, caught a remote-control helicopter with a package slung underneath it. Drone intrusions into prisons have become increasingly commonplace. A quadrotor carrying drugs crash-landed in the exercise yard of Wheatfield Prison in Dublin; another was found in the grounds of a jail in South Carolina loaded with mobile phones and marijuana. Similar stories have cropped up recently in Australia, Brazil, Canada and many US states, and in 2015 we'll hear more wherever prisoners have outside access.

Serious smugglers will want bigger drones. Last May, Russian border guards intercepted an unmanned aircraft with a four-metre wingspan entering the country from Lithuania. It was carrying 10kg of cigarettes and could release them over a GPS-designated drop zone. With a £2 profit per pack, the drone was

SPOT ILLUSTRATION: JAMIE JONES

offering smugglers £1,000 per flight.

According to the US Drug Enforcement Administration, South American drug cartels that previously built submarines are now building drones. These fly low over the US-Mexico border with tens of kilograms of cocaine. The payload is far less than a sub, but smugglers can reportedly buy two-dozen drones for the price of a submarine, and they make more trips. Even if they run a greater risk than a submarine of being caught, enough drones make it over the border for it to be profitable. The next generation of smuggling drones is likely to be to be more sophisticated, stealthier and far more numerous.

Perhaps our most serious worry is that terrorists will start using drones to circumvent security measures. In 2012 Rezwan Ferdaus was convicted in the US of plotting an attack with three remote-controlled model planes packed with C-4 explosives. He had already prepared the first one, and the plot was taken seriously enough to earn him a 17-year sentence.

Ferdaus had to assemble his drone, but now you can buy one and fly it out of the box – and target politicians. In Germany, the Pirate Party crashed a quadrotor on to the podium in front of Angela Merkel during a political meeting. In the coming year we are likely to see further drone-based direct action – if not actual assassinations.

The easy availability of drones for all in 2015 is going to rewrite the rules for a lot of things – and crime will be near the top of the list.

David Hambling wrote about uncriminal quadrotors in The WIRED World in 2014

RESPIRE

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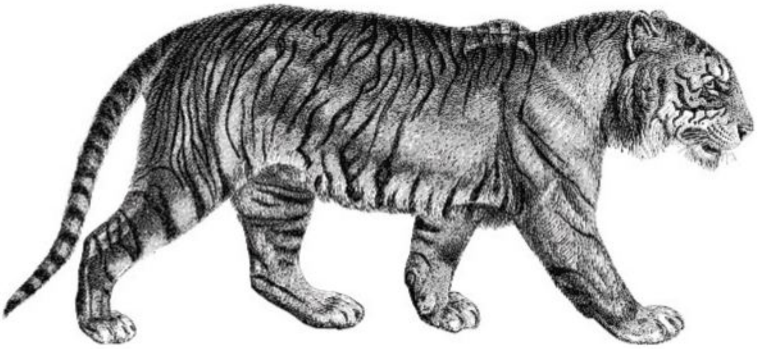
An app that allows users to control games by breathing will go on sale in 2015. *Zenytime*, which also monitors oxygen levels, claims to help players relax and exercise more effectively.



TIGER. *Panthera tigris*. FACING EXTINCTION.

Nature needs big cats, and big cats need big spaces

Everywhere that big cats are found they are at the top of their food chains. They are ancient predators essential to the balance of their environments. Without them, the biodynamic orders of the areas they have dominated for thousands of years would collapse, leaving us with a natural world bleaker and less varied than ever before.

All of the world's big cats – from cheetahs to jaguars and pumas – are now under threat. Development and the swell of human populations in previously wild areas is robbing these animals of their habitats and the wilderness of its dignity.
In many of these environments, these increasingly rare animals are still hunted for body parts and sport, too.

At the World Land Trust, we are working with 29 organisations in 22 countries to enable local communities to buy and save parcels of land for permanent conservation, and to work with local communities to find ways for them to live in harmony alongside big cats.

We urgently need to raise £500,000 to preserve the most important remaining big cat habitats. Nature as we know it is disappearing and the only time we have to save it is now.

For more information go to *www.worldlandtrust.org*

"The money that is given to the World Land Trust, in my estimation, has more effect on the wild world than almost anything I can think of."
— *Sir David Attenborough*, Patron, World Land Trust

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ROBOT PROPAGANDA

Artificial intelligence and learning algorithms will make it almost impossible to tell robots from humans – and real news from fake. So what's on the agenda?

By **Sean Gourley**

HUMANITY HAS BEEN ADVANCING the field of propaganda for as long as we've been at war or had political fights to win. But today, propaganda is undergoing a significant change based on the latest advances in the fields of big data and artificial intelligence.

Over the past decade, billions of dollars have been invested in technologies that customise ads increasingly precisely based on individuals' preferences. Now this is making the jump to the world of politics and the manipulation of ideas.

Some recent military experiments in computational propaganda indicate where this could be taking us. In 2008, the US State Department, through its "foreign assistance" agency USAID, set up a fake social network in Cuba. Supposedly concerned with public health and civics, it's operatives actively targeted likely dissidents. The site came complete with hashtags, dummy advertisements and a database of users' "political tendencies". For an estimated $1.6m (£1m), USAID was, between 2009 and 2012, able to control a major information platform in Cuba with potential to influence the spread of ideas among 40,000 unique profiles. Building on this project in 2011, USCENTCOM (United States Central Command) – the US military force responsible for operations in the broader Middle East region – awarded a contract to a Californian firm to build an "online persona management service", complete

DECEMBER 31, 2015

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The EU-Ukraine-Russia trade agreement begins. Former Ukrainian president Viktor Yanukovych's refusal to sign it in 2013 sparked the pro-Europe protests.

ILLUSTRATION: JOE WALDRON

with fake online profiles that have convincing backgrounds and histories. The software will allow US service personnel to operate up to ten separate false identities based all over the world from their workstations "without fear of being discovered by sophisticated adversaries". These personas allow the military to recruit, spy on and manipulate peoples' behaviour and ideas.

Such projects represent the first wave of computational propaganda, but they are constrained in their scale (and ultimately their effectiveness) by the simple fact that each profile has to be driven by an actual human on the other side. In 2015, we will see the emergence of more automated computational propaganda – bots using sophisticated artificial intelligence frameworks, removing the need to have humans operate the profiles. Algorithms will not only read the news, but write it.

These stories will be nearly indistinguishable from those written by humans. They will be algorithmically tailored to each individual and employed to change their political beliefs or to manipulate their actions. Already, Mexican drug cartels have employed propaganda bots to target messages at individual members of the public, to convince them that the death of a journalist in Las Choapas had nothing to do with hit men employed by the gangs. This type of propaganda can be produced at an almost limitless scale using the estimated ten million social-media bots. Such bots are currently available for rent on online hacker forums for between $5 and $200 per thousand, depending on how "human" – and therefore how effective – they appear.

The Russian foreign intelligence service has announced a 30-million-ruble (£500,000) contract for the "development of special software for automated information dissemination in major social networks". In 2015 we will also see the first results from initial field tests of the US IARPA (Intelligence Advanced Research Projects Activity) project to deploy propaganda bots in South America in an attempt to influence local political opinion.

MIXED RESULTS

Eight "Millennium Development Goals" were outlined by the UN in 2000, with a deadline of 2015. Some nations did well – China reduced its population in poverty by half – but globally, results are less promising: 162 million children will still go hungry.
Thomas Hale

It is still early days – many of the bots deployed in 2015 will be programmed to use relatively simple heuristic techniques to imitate intelligence. But, powered by rapid advances in artificial intelligence, propaganda bots will soon run on genetic algorithms that let their ideas and messaging evolve, based on the resonance and effectiveness of previous messages. We are likely to see versions of these bots deployed on US audiences as part of the 2016 presidential election campaigns, and not only by the traditionally more tech-savvy Democrats.

This technology exploits the simple fact that we are much more impressionable than we think. Facebook's recent experiments to modify users' moods show us that the very language we use to communicate is subject to manipulation based on the stories that the Facebook algorithm chooses to show us. Furthermore, researchers at MIT have shown that a false upvote cast early on can improve the public response to a story by 25 per cent; a single early downvote can make an otherwise good story be perceived as a low-quality piece of journalism. In 2015, the propaganda bots will start to use this knowledge to influence news feeds – automated "friends" will like, retweet and comment on stories that are in line with their propaganda goals.

We can also employ bots to help us determine if there are attempts at propaganda underway. Reactions to the downing of Malaysian Airlines flight MH17 over Ukraine show that the Russian and US media want the global audience to view things differently. We can employ algorithms to monitor mainstream media messaging out of Russia, compare that to what we are seeing in the US outlets, and flag substantive differences in language. We can also employ bots to monitor all of the millions of edits that happen daily on sites such as Wikipedia and uncover attempts to change language from "terrorists" to "Ukrainian soldiers", though it won't tell us which version is true. For that we still need humans to weigh the evidence.

Sean Gourley is CTO of Quid, an augmented intelligence company

1.4 MILLION

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Predicted Ebola infections in West Africa by 2015, according to the US Centers for Disease Control and Prevention. A US-developed vaccine is due that year.

DIGITAL LAWS EVOLVE

As big data seeps into every aspect of daily life, the law will catch up and introduce a raft of essential new e-regulations

By **Neil M Richards**

THE LAW HAS ALWAYS BEEN SLOW to keep up with technology, but in 2015 we will see increasing regulation. Over the past decade, as the web, social, mobile, cloud and big data phases of the digital revolution have leapt forward, regulators have been reluctant to intervene. After all, law can be a blunt tool, and

SPOT ILLUSTRATION: JAMIE JONES

it is all too easy for even well-meaning lawmakers to issue rules that later turn out to be restrictive.

But as the scope and scale of the digital transformation has become apparent, regulators have woken up. Surveillance reform is on the agenda around the world, and so is privacy law more generally, such as the revision of the EU Data Protection Directive and serious efforts at reform by the White House, the Federal Trade Commission, and other parts of the US government. The decision by a Spanish court earlier this year requiring Google to filter its search results to protect privacy under what is colloquially known as "the right to be forgotten" is part of this trend.

But more change is on the horizon. Surveillance law will adapt to include the cloud, and it will no longer be acceptable for governments to use "we collected the data because it wasn't prohibited" or "anything shared on the internet is fair game" as a viable excuse for intrusions into their citizens' privacy.

As big-data predictions start to affect more of our lives, we'll see new protections come into force against discrimination by algorithm, whether by security services, insurance companies or employers. As the sensor-enabled "internet of things" promises to turn every electrical device (and quite a few that aren't) into a data-collecting networked appliance, and as smart watches and wearable tech such as Google Glass proliferate, we'll need rules for the data that is collected: who owns it, for what purposes and for how long? As long as technology was largely confined to cyberspace, it was relatively easy to keep things separate. But as our digital technologies increasingly enter physical space, law will find itself entangled in these new and important questions – whether it wants to be or not. Already, companies are starting to hire "chief privacy officers" in record numbers, and new law graduates throughout the western world are finding that the high-growth area within law firms is in its privacy-law practices.

We have seen this pattern before. At the very dawn of the digital age, cyber-utopians argued that law had no place in our new digital realm. But, as it turned out, laws were in fact necessary – to provide a basis for digital property and digital commerce; to provide security from scammers and malicious hackers; and for the redress of the many crimes and wrongs that would inevitably occur as major chunks of human life migrated to digital formats. The best example of this was in the area of copyright, when perfect, cost-free digital copying threatened the long-established economic model of many of the industries that make culture: music, books and film. For a while, we stared into the abyss of a revolutionary Napster and YouTube future, and then we pragmatically backed away, bringing copyright law into the digital realm. Many of us believe that copyright law actually went too far, but the clear lesson is that if law can regulate copyright for the entertainment industries, it can – and should – regulate data for everyone else.

And it will. As the digital revolution proceeds, we're realising that we have a right to demand that privacy, security, expression, equality and other values we fought so hard to get built into the democratic society of the twentieth century get built into the digital one of the twenty-first. In 2015, these developments will kick into high gear, and law will start to catch up with technology.

Neil M Richards is professor of law at Washington University

LAND GRAB

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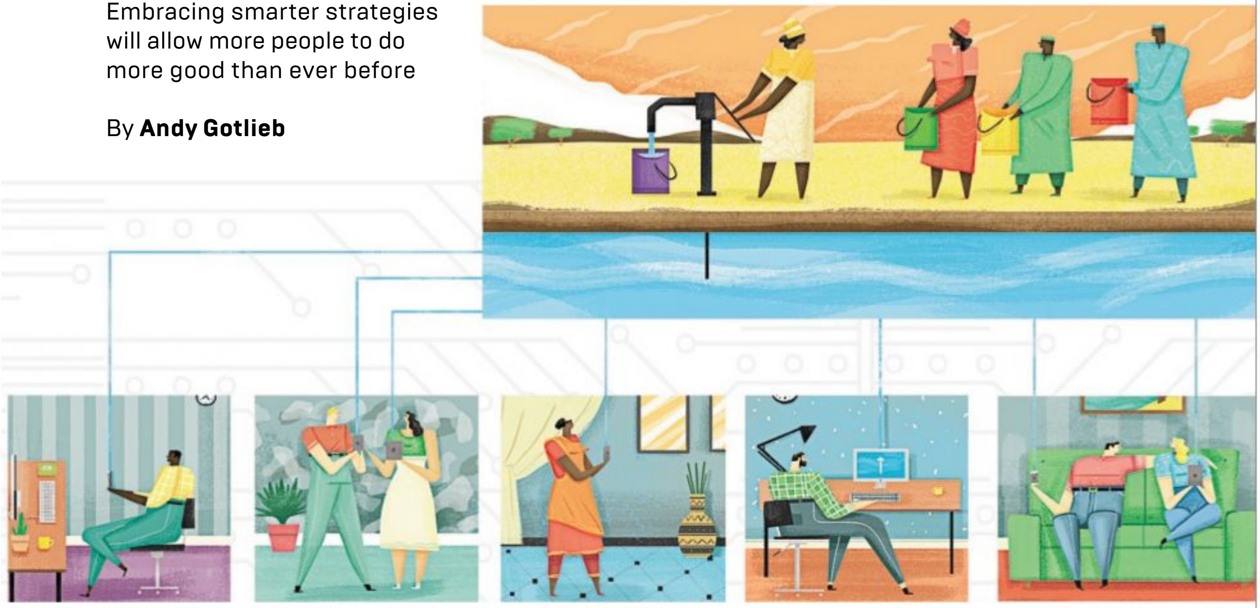
In 2015, China will complete a round of island-building in the South China Sea, turning reefs into atolls to bolster its claims to valuable strategic maritime territories. TH

SOCIAL INNOVATION HITS THE MAINSTREAM

Embracing smarter strategies will allow more people to do more good than ever before

By **Andy Gotlieb**



SOCIAL INNOVATION, A CONCEPT THAT has built momentum over the past five years, will rise up the news agenda in 2015, thanks to crowdfunding and social media.

Let's take Stanford University's Center for Social Innovation's definition of the term: "a novel solution to a social problem that is more effective, sustainable or just better than present solutions – and for which the value created accrues primarily to society as a whole than to private individuals".

The concept isn't new – Benjamin Franklin said social modifications within a community could help solve everyday problems. But it is now being repurposed for today's tech-savvy generation.

At the UN's 2014 Social Innovation Summit at its New York HQ in May 2014, three keys to a breakthrough in social innovation initiative were outlines.

The first, obviously, is innovation, via a disruptive idea or technology with the power to transform the status quo and change lives. In 2015, this will be supported by an increased awareness of branding: "Speak to the heart to move the mind," as filmmaker and summit speaker Patrick Moreau said.

Second, practitioners have learned to develop a brand narrative that incorporates video, leveraging social media for a powerful multiplier effect.

Thirdly, metrics – setting goals and measuring their impact. We are used to counting page views, but pounds raised will be just as relevant. Social entrepreneurs will be replacing mailouts and mass-media ads with a strong digital presence to raise funds (such as Kickstarter), and using social media to fine-tune their messages. That will propel the movement to the philanthropic mainstream.

Andy Gotlieb is a consultant for the Garfield Group in Newtown, Pennsylvania

CLIMATE CHANGE

In December 2015, the 194 countries that have been negotiating a treaty to address climate change may finally come to agreement – because time will have run out. Climate scientists warn that if no deal is reached in 2015, prospects for limiting damaging changes will fall sharply. But there is cause for optimism; new policies in the US and China have brightened prospects for a workable deal. **TH**

NON-VIOLENT RESISTANCE TAKES ON HI-TECH WARFARE

From armed drones to switching off social media, oppressive regimes will up their game in an attempt to squash dissent

By **Srdja Popovic**

THE WORLD MOVEMENT FOR SOCIAL change, which we might call the Global Spring, will enter a new phase of sophistication in 2015. Frightened by the people power that has been unleashed, governments will invest heavily in technology to combat non-violent movements. Meanwhile, pro-democracy activists will use "hacktivism" and creativity to counter high-tech suppression.

After activists mastered technology, from the Arab streets to Wall Street in 2011, dictatorships and kleptocracies quickly learned that the whole world was watching. Whereas they once relied on the power of brute force, they will increasingly opt for less visible forms of control. There will be fumbles in the battlefield of technology, such as Russian president Vladimir Putin's claim that the CIA invented the internet. And there will be blunt censorship, such as Turkish prime minister Recep Tayyip Erdoğan's attempt to "wipe out Twitter". But we can expect new levels of proficiency as well.

In June of 2014, a South African-produced riot-control drone was unveiled at the IFSEC (International Fire and Security Exhibition and Conference) trade show in London. Nicknamed "The Skunk", this flying riot-police officer is armed with pepper spray, plastic bullets, pellet dye-markers, thermal cameras and strobe lights. A mining company in South Africa has placed the first order. The Brazilian police also deployed drones to monitor activists during the much-protested World Cup in the summer of 2014. Among the devices also picked up in its $900 million dollar security-spending spree were "Robocop" police helmets. Using facial-recognition software they could upload 400 images per second into a central database – crowd-roaming robots were equipped with the same technology. This is what activists will be up against, and the trend will continue.

In 2015, there will be widespread innovation in the internal security sector, which is expected to grow by 20 per cent over the next five years. Governments will deploy "non-lethal" technologies to suppress freedom of speech. For they have seen that making a show of killing peaceful protesters incurs international outrage and national backlash.

RAPPROCHEMENT

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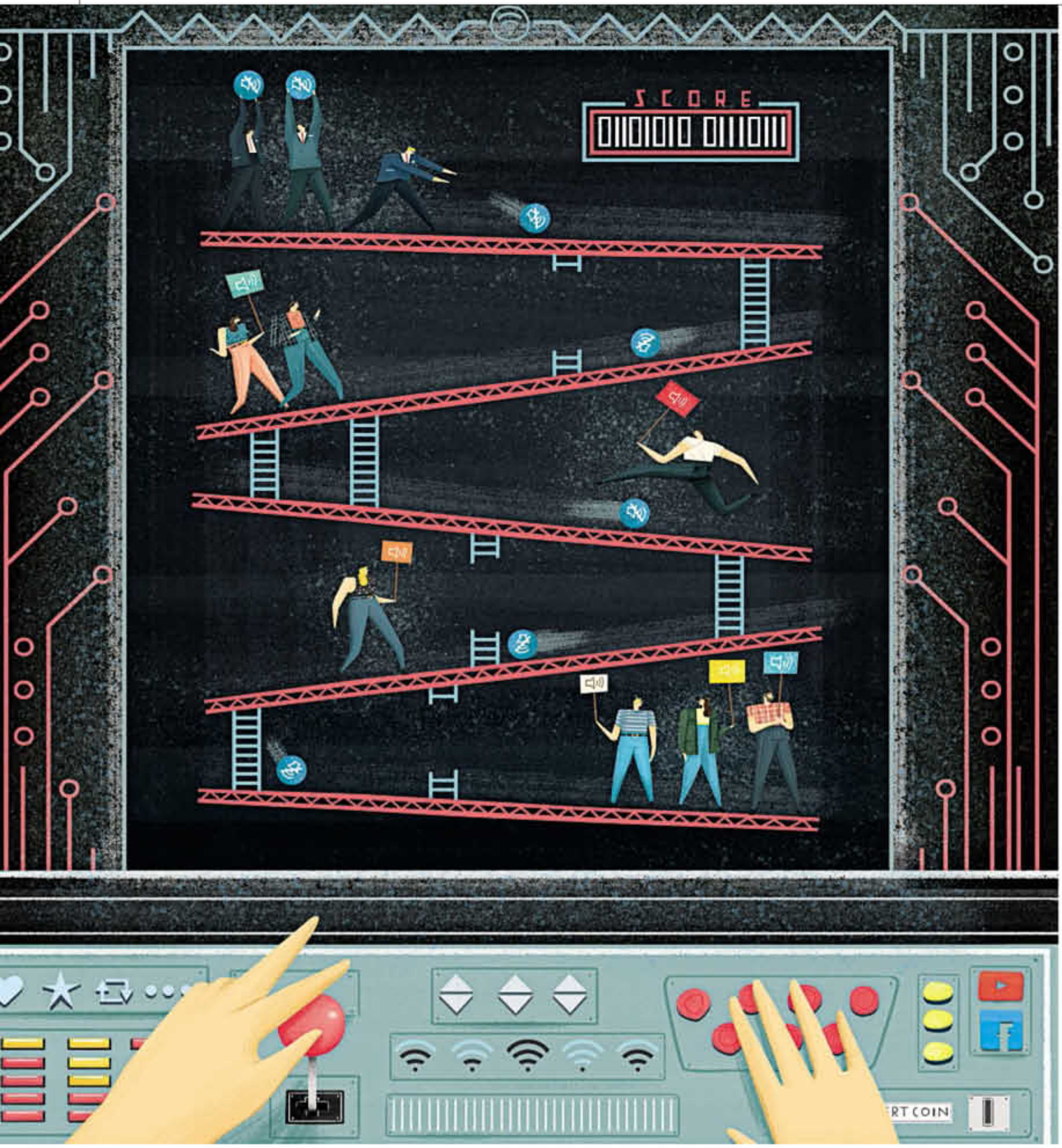
The west's campaign against ISIS may thaw relations with Iran, which is also working against the fundamentalist group. Diplomatic progress on Iran's nuclear programme could result. TH

Activists will be countering. Mobile-encryption specialists Silent Circle and Wickr will provide activists with sophisticated encrypted communication services via smartphone apps. Google's "Project Shield", offers civil rights and media groups free protection from distributed denial of service (DDoS) attacks, whereby a website is disabled by a surge of malicious traffic. By allowing such groups to use Google's own robust infrastructure, such attacks can be mitigated. In San Francisco in August 2014, the Human Rights Foundation – a group dedicated to getting information to dissidents and citizens in North Korea, organised a hackathon to generate new ideas and technologies to this purpose. In 2015, non-violent movements will increasingly place "hacktivism" at the core of their strategies.

But there will be even bigger surprises ahead. When the Egyptian government tried to shut down the internet in January 2011, activists formed the Open Mesh

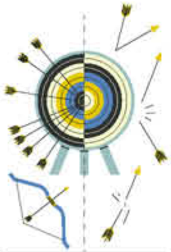


Project to promote and develop the use of "mesh networks". These are local networks capable of connecting computers directly to one another without a centralised server.

This technological chapter in warfare will favour grassroots movements, for it will allow activists to make gains with slim infrastructure. This is already evident in viral videos that garnered huge numbers of views, such as 2014's YouTube video *I am a Ukrainian*. Directed by US documentary filmmaker Ben Moses, the 2min 4sec short features photographs of the protests, shot by British photographer Graham Mitchell, and an anonymous Ukrainian woman (later identified as PhD student Yulia Marushevska) explaining the situation. It has been viewed more than eight million times. Yet this freedom from infrastructure will present new problems. The Occupy Movement gained traction through the power of social media, but it lacked the strategy and organisation to direct its energy into concrete victories.

Activists will not buy into the superficial idea, frequently heard in 2011, that a revolution can be made by Twitter. There is no substitute for the everyday concerns of real people who have a strong strategy and creative tactics. In one of the lowest-tech societies in the history of non-violent conflict, South Africans used songs with cryptic lyrics to convey political messages as a subtle method to unite the anti-apartheid movement during the 80s. This tactic could still thwart many of today's sophisticated anti-activism techniques. It won't be technology but activists on the ground who ultimately win or lose the war.

Srdja Popovic is executive director of the Centre for Applied Non-violent Action and Strategies, based in Belgrade, Serbia, and a visiting scholar at the School of International Public Affairs at Columbia University



MARRIAGE VOWS

A string of victories for gay-marriage advocates in the US has (at the time of writing) brought the number of US states now recognising marriage equality to 32. In 2015, it is likely that the US Supreme Court will be asked to rule to apply the policy to the other 18. The decision will either give all Americans the right to marry, or set up more years of state-by-state campaigning. **TH**

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THE DAWN OF A NEW CREATIVE ECONOMY

Smartphone tools and direct-to-fan services give today's innovators an edge over the incumbents. Prepare for a talent explosion

By **Saul Klein**

WE WILL SOON ENTER A NEW CREATIVE economy. Creative talent is surging back to life as the cost of production and distribution falls to a level where artists can build direct relationships with their audience, change the balance of power with labels, studios and publishers, and find new ways to profit from their work.

By 2015, there will be more than two billion smartphones in the world. Almost all of those devices will pack a smart keyboard, speakers that support wideband audio, back- and front-facing cameras, beamforming microphones and HD video. These are power tools for creative producers, and, with a legion of post-production apps designed for them, these devices have empowered a new pool of talent.

The wide availability of these tools doesn't necessarily mean that in 2015 design, art, media and other creations will be any better than before. But when you marry this proliferation of content to online distribution platforms with unprecedented reach, it changes the way talent can emerge.

In 2015, the battle among the major creative platforms will no longer just be about reach – it will be about tools. Early winners such as iTunes and Amazon will increasingly be at a disadvantage if they continue to allow platforms such as YouTube, SoundCloud, Twitter, Spotify and Wattpad take the lead in building better tools for creators. Artists are assembling huge followings on social platforms, and are able to manage those relationships with increasingly sophisticated technologies.

Talent such as British spoken-word artist Suli Breaks, whose YouTube videos have been seen 15 million times, are building dedicated online fanbases. Artists are emerging from social platforms in the same way that Justin Bieber sprang from YouTube and Lorde from SoundCloud, and are being folded into the mainstream media machine.

But these are artists who fit a conventional mode. In 2015, greater opportunities will accrue to talent such as violinist Lindsey Stirling, who might never have found a mainstream audience, yet who has translated her five-million-plus YouTube followers into a superb career with superior economics. The game has changed – ask Notch from *Minecraft* creator Mojang, recently bought by Microsoft for $2.5 billion (£1.5bn), who has the whip hand when he negotiates with LEGO for toys and Warner Bros for movies.

FILM WARS

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The highest-grossing film of all time, 2009's $2.7-billion-earning *Avatar*, could be overtaken by *Star Wars: Episode VII* on its release in December 2015, analysts have predicted. Oliver Franklin

This new generation of artists will not entirely turn their backs on smart publishers, studios and labels, but the conversations will change. They will come to the table with much more, which changes the dynamic. In some ways this is similar to the changes that app stores, accelerators and crowdfunding platforms have wrought between entrepreneurs and VCs.

Smart artists in 2015 will use crowdfunding as a matter of course to underwrite their productions. Any conversation with a label, studio or publisher can then start with: "What can you do for me?" Fans will be part of this movement – helping the next Macklemores emerge in every genre and in every form of the arts. They will back film-makers on Kickstarter who will go straight to Netflix. They will be among the 20 million readers that writers such as Brittany Geragotelis attract on Wattpad. This is the year when artists and their fans lay the foundations for the new creative economy.

Saul Klein is a partner at Index Ventures, which has invested in startups including SoundCloud, Sofar Sounds and Patreon

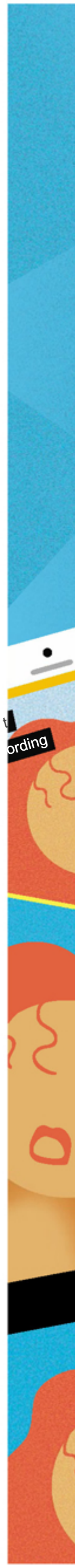

ILLUSTRATION: **JOSH MCKENNA**

NEWS-FINDING GOES VIRAL

Now breaking: the deep web, space sensors, crowdsourced apps and Google Glass will upend the traditional newsroom

By **Ed White**

THE NEWS BUSINESS IS HAVING THE first glimmer of a renaissance, thanks to the rise of wearables, big data, the deep web, drones and sensors.

Vying to scoop Fleet Street are "full stack" startups such as Vocativ, Mic and OZY – digital- and mobile-first news organisations that are hoovering up tens of millions of digitally native readers accustomed to reading on smartphones rather than on paper.

All of these companies are testing new models for sniffing out stories. Vocativ has hired technology, ex-military and Wall Street experts to create proprietary software Open Mind to mine the deep web and unindexed information. It is teaming journalists with expert analysts to unearth and report untapped stories.

DRONES JOIN THE BIG TOP

Autonomous aerial performers will become more commonplace. Cirque du Soleil has demonstrated as such in a short film, *Sparked,* produced in collaboration with Zurich's ETH university. It features a human performer interacting with ten quadcopters moving on pre-programmed flight paths. **OF**

Nate Silver's FiveThirtyEight blog has pioneered data journalism, but as low-cost sensors gather more real-time data from the physical world, "sensor journalism" will emerge. Expect more experiments such as US radio station WNYC's 2013 Rise of the Cicadas project in 2013, which urged listeners to create DIY temperature trackers to help predict when the elusive insects would appear. Participation in news is shifting too, with user-generated content transforming into platforms such as mobile app *Five-0*. Developed by three teenagers in the wake of Michael Brown's shooting in Ferguson, it allows people to report incidents of police brutality.

Paparazzi drones have already caught the headlines in the last 12 months, but go higher and you'll notice that space has also become democratised, through remote sensors on satellites. Watch out for remote sensing helping to set the news agenda.

At the same time, the rise of wearables, big data and predictive analytics will create new glimpse-friendly form factors – bite-sized, personalised and contextual. Already some American newsrooms have been examining what Google Glass means for reporting and user-generated content. CNN has launched iReport, its Google Glass reporting tool. And sharp-eyed commentators spotted the Yahoo! News Digest icon in Tim Cook's Apple Watch presentation last September in Cupertino.

As billions more people get online, the market for news will vastly expand. This didn't escape Amazon's Jeff Bezos, who snapped up the storied *Washington Post* for $250 million (£216m). Or eBay's Pierre Omidyar, who's spending $250m to set up digital magazine publisher First Look Media. Youth media company Vice, meanwhile, recently picked up $500m in further funding.

"I am more bullish about the future of the news industry over the next 20 years than almost anyone I know," says Andreessen Horowitz cofounder Marc Andreessen. "You are going to see it grow ten times to 100 times from where it is today."

Ed White wrote about structured serendipity in The WIRED World in 2013

A VIRTUAL DIMENSION FOR FILM

Oculus Rift will make inroads into Hollywood in 2015. Studios such as Lucasfilm and Legendary Pictures are experimenting with virtual-reality content, and San Francisco startup Jaunt VR, which creates 360° filming rigs, has partnered with New Deal Studios to produce an exclusive short for the device. **OF**

AUTOMATED ADVERTS IN YOUR FEED

Advertising will enter a new era, with algorithms honed to match you with products in nanoseconds

By **Madhumita Venkataramanan**

THE DIGITAL ADVERTISING INDUSTRY is falling prey to the bots. According to the Interactive Advertising Bureau UK (IAB), in 2015 almost 60 per cent of online display ads will be bought and placed by algorithms, rather than humans. "[Automation] allows advertisers to target the audience they want on an individual basis and in real time, rather than buying in bulk," says Steve Chester, director of data and industry programmes at IAB. The proportion has grown from 28 per cent in 2013 to 47 per cent in 2014, with the curve set to rise in the next five years.

Compared to traditional ad buying, whereby agencies and marketers must make educated guesses at who their audience is, this "programmatic" buying uses algorithms to analyse and automate the delivery of real-time ads to targeted consumers, based on highly accurate personal details about them.

"You can buy socio-demographic data about a user's IP address, such as the affluence in their geographical area, from Experian," says Chester.

Other personal data is compiled through cookies on the user's browser which track online activities and segments consumers based on their interests. Heavyweight brands like American Express, Procter & Gamble and GroupM have all announced plans to automate the majority of their digital media spend in 2015.

The way programmatic advertising works is similar to an algorithmic stock-market trade. Take Facebook ads: advertisers seek to target, say, a well-to-do 30-year-old man who just bought his first home. When you launch your Facebook page, it knows who you are within nanoseconds. If your profile is a match, Facebook will offer it up auction-style and the advertisers' algorithms will bid against each other to place an ad on your feed. "In between you opening the page and the advert appearing, the transaction has taken place," says Coca-Cola marketing veteran Maarten Albarda. "If nobody buys your profile initially they place it on an open exchange where it's cheaper. Everything you see is through that nanosecond trading system."

Stock-market trading followed a similar trajectory: "Between 2007 and 2012, automated stock-market trading went from 25 per cent to 65 per cent," says Albarda. "Two-thirds of people doing those trades lost their jobs. That's why agencies are interested. Having higher profits and lower operating costs is an advantage for them."

It's not just the desktop web that is increasingly serving automatically targeted ads; location-based mobile ads, radio and TV will also be impacted. "Because cable companies and TV manufacturers know a lot about who is watching in each house, they could serve targeted ads in your home, whereas your neighbour would be shown a different ad at the same time," says Albarda. SKY TV in the UK, the Dish network in the US and Samsung smart TVs in Europe are all beginning to offer programmatic ads. "We are at a watershed moment with this technology," says Albarda.

Madhumita Venkataramanan is WIRED*'s associate editor*

BLU-RAY FIGHTS BACK

Cinema-quality, ultra-HD DVDs will go into full production in 2015, as the optical-disc industry responds to the runaway success of streaming services such as Netflix. The discs, which use 4K Blu-ray, will deliver a resolution of 4,096 x 2,160 pixels, four times the current full HD specification. Discs and players will go on sale in time for Christmas. OF

THE RETURN OF NEWSPAPERS

A radical rethink in the way media companies operate and publish their news will prompt an upturn in the so-called fading fortunes of newspapers and magazines

By **Deborah Bothun** and **Chris Lederer**

THE MAGAZINE AND NEWSPAPER industries are about to reverse a multi-year downward trend to begin a regenerative growth path. Digital growth will accelerate global magazine revenue as emerging-market readership increases are likely to nudge newspaper revenue upward.

Print publishers are increasingly adopting a digital-first strategy in their efforts to attract connected subscribers and digital advertising revenue, reversing an age-old trend of developing content for print first, then adapting that content for digital media. Most major newspapers now operate newsrooms that integrate digital content, in particular video content, upfront in the production cycle. Likewise, in the magazine industry, publishers are increasingly going digital first. Their efforts will focus on publishing content that works best on mobile devices. Some in the industry, including mobile and online companies, now talk to advertisers about a "mobile first" approach, as more consumers are getting more accustomed to consuming on smartphones.

According to Scott Schulman, president of US publisher Rodale, digital first can serve customers better, save money, excite editorial talent, and help both print and digital businesses.

"It helps us produce a better magazine because after we run the digital stories we get immediate feedback about what users cared most about, which helps us curate a tonne of content into the most resonant magazine possible," he says. "This strategy has given great results at brands such as [consumer health magazine] *Prevention*, which is the number-one print magazine in US news-stand growth through mid-year 2014, and at *Women's Health*, which has grown its digital audience by 102 per cent in 2014 and is number four in news-stand growth."

In aggregate, global digital magazine gains outpace falling print revenue, and the industry is likely to chalk up record growth, with revenues reaching more than $98 billion (£59 billion) by 2018, according to PricewaterhouseCoopers Global Entertainment and Media Outlook 2014-2018. For consumer magazines in particular, digital subscription revenue growth is likely to move from four per cent of revenue in 2013 to 14 per cent by 2018.

In 2015, global newspaper revenue will start to climb again as growth in developing countries begins to surpass the slump in mature markets. Most of these countries are in the Asia-Pacific region, especially China and India, where print is actually continuing to grow. However, growth in these countries is likely to stabilise by 2018, and the way publishers monetise their newspapers will also become more typically digital. Unlike magazines, global circulation revenue will almost match advertising revenue by 2018.

In more mature markets, however, newspaper growth will continue to stall, and this may be the beginning of the end for traditional print newspapers. Publishers are beginning to develop over-the-top video networks, explore better ways to measure (and promote to advertisers) the digital engagement of readers, and test new content marketing programmes for their journalism. Content marketing, or native advertising, has also been a promising investment area.

In 2015, the publishers that succeed in connecting, informing and entertaining their readers within this new digital reality are likely win out during this rebound.

Deborah Bothun is US entertainment, media & communications (EMC) leader at PwC. Chris Lederer is principal, EMC strategy practice at PwC US

BBC THREE GOES ONLINE

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The BBC will join the growing number of companies competing in the on-demand TV arena when BBC Three moves online-only in autumn 2015. OF

SPOT ILLUSTRATION: JAMIE JONES

TECH TO APPEAL TO THE SENSES

Haptic technology, virtual reality and scent-producing plug-ins will ensure our entertainment will not be confined to sight and sound

By **Ed White**

HALF A CENTURY AGO, AN INVENTOR called Morton Heilig created the Sensorama. Essentially an armchair equipped with fans and speakers, it enhanced films with scents to create a more visceral experience, transporting audiences into Brooklyn, for example, on a motorbike, wafted by cheap perfume and the smell of pizza. The impractically expensive Sensorama never took off. But 50 years later, cheap sensors, actuators and processors mean immersive, multi-sensory experiences are offering new opportunities to the gaming, TV, film and theme-park industries.

Virtual reality, once a geeky, niche field, will soon become mainstream, with some analysts predicting the sector will be worth $5 billion by 2018. Facebook's Oculus Rift, Sony's rival headset Project Morpheus and products such as Valve's Polka Dot will be joined by the likes of Samsung and Google, which are developing cheap, smartphone-powered products that point to a headset-filled future. Portal Entertainment's *The Craftsman* is a real-time horror mystery that uses accelerometers, GPS, notifications and even phone calls to suck participants into an unsettling voyage that blurs physical and digital storytelling. Google's film *Windy Day* and ApeLab's *IDNA* animation allow screen content to interact in new ways with the physical world.

Enhancement will also go beyond sight and sound. As more experiences become "software wrapped in plastic", as Foundry Group's Brad Feld neatly put it, the blurring of physical and digital offers new possibilities. Australian sports fans will be able to experience the games they're watching more viscerally, for example, by wearing the Alert Shirt created by the broadcaster Foxtel. This haptic vest reproduces a football player's heart rate and the sensation of being tackled via a smartphone app.

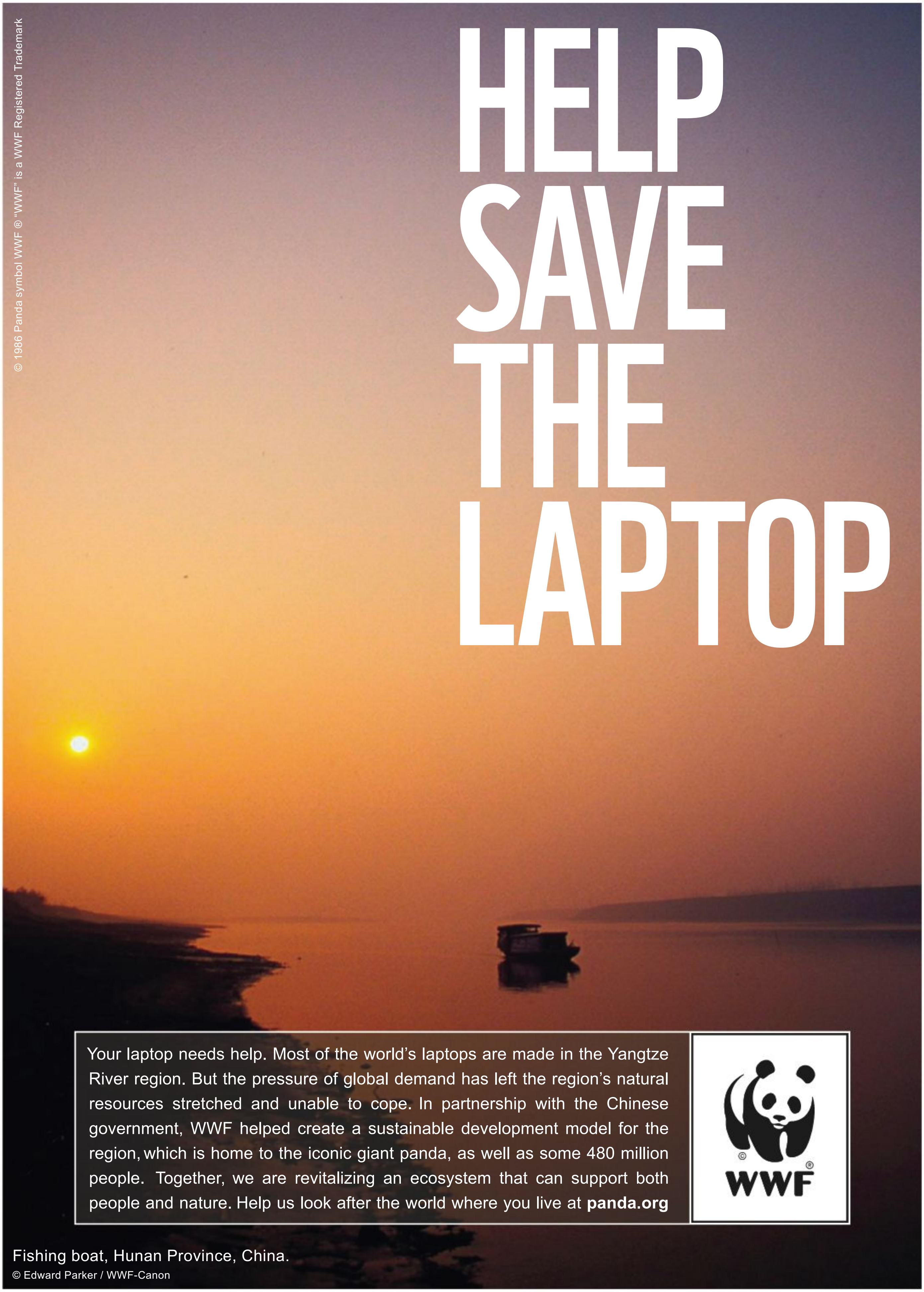
Early in 2014, Nimesha Ranasinghe at the National University of Singapore unveiled a device that uses tiny electrical currents to stimulate taste buds. She hopes that viewers might soon be able to taste recipes cooked up by TV chefs. Adrian Cheok, director of the Mixed Reality Lab at City University, London, is researching a multisensory web, including a smartphone plug-in that transmits someone's scent, a "kissing machine" that allows people's smooches to be physically recorded and transmitted afar, and – like Ranasinghe – a digital taste-stimulator. Cheok is working with Michelin-starred restaurant Mugaritz in Spain to let prospective diners smell dishes from the menu through their smartphones. He's also created an alarm clock app and plug-in for US food brand Oscar Mayer, which enables users to wake up to a sizzling sound and the smell of bacon.

Disney Research is developing haptic technology for its theme parks that will use electric currents to change the feel of surfaces, making a wall feel furry, for instance. Its Aireal project will produce touch sensations using pulses of pressurised air. A projected animation of a butterfly will land on your arm and you will be able to feel its wings against your skin. And Disney's Botanicus Interacticus project can turn house plants into a musical instruments. Look out for these in a theme park near you in 2015.

Ed White wrote about structured serendipity in The WIRED World in 2013

SMARTER SHIRTS

Ralph Lauren's Polo Tech Shirt, developed with Canadian biometric sportswear startup OMSignal, comes to market in 2015. Tested at the US Open, the unisex T-shirts use silver-coated thread and sensors to measure heart-rate, calorie consumption and stress levels. OF



Your laptop needs help. Most of the world's laptops are made in the Yangtze River region. But the pressure of global demand has left the region's natural resources stretched and unable to cope. In partnership with the Chinese government, WWF helped create a sustainable development model for the region, which is home to the iconic giant panda, as well as some 480 million people. Together, we are revitalizing an ecosystem that can support both people and nature. Help us look after the world where you live at **panda.org**

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Fishing boat, Hunan Province, China.

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BUSINESS

FEATURING WRITING BY **EDEN SHOCHAT, TEJ REKHI, JOHN COATES, JAKE CHAPMAN AND KATIE COLLINS**

CRYPTO-COINS COME OF AGE

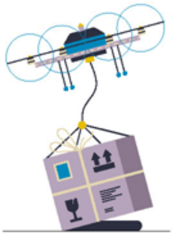
By combining currency with functionality, bitcoin clones will solve all kinds of financial problems, and let anyone hold an IPO

By **Eden Shochat**

STARTUPS WILL BE RAISING MONEY in a new way in 2015 – one that is outside traditional venture-capital systems and using currencies that don't even exist today. They will be able to do this because of an untapped feature of crypto-currencies such as bitcoin – the ability for anyone to create new forms of money. An early example is MaidSafe, an open-source company building a decentralised version of the internet. Instead of using specialised servers, data is stored and distributed by a network of internet-connected computers. MaidSafe handles the allocation of hard disk space and communication between the computers. The firm closed an $8m (£5m) investment round within 48 hours in May 2014. But it's not a high-flying Silicon Valley startup launched by the "PayPal mafia". MaidSafe is a company operating out of the small town of Troon in Scotland – a venture-capital-free zone.

MaidSafe was the first business to take full advantage of Mastercoin, an early Bitcoin 2.0 platform. For all intents and purposes it has carried out an initial public share offering (IPO), although it avoids the term for regulatory reasons, as an IPO of shares to the public today is such a complex officiated process that it takes a company years to prepare for. Other terms, such as "currencies", also have a regulatory burden, causing many recent offerings to use the word "tokens". Bitcoin 2.0 is creating an infrastructure that is enabling all sorts of network models, applications and tokens that will drive financial innovation for the next decades.

MaidSafe created a new currency, or token, on top of Mastercoin's platform, that it calls a "safecoin". Safecoins are exchanged between users whenever nodes (computers) in the MaidSafe network transmit and store data between them. When a server or a user's computer stores information



INTO THE AIR

Drones will continue to grow in sectors such as e-commerce. In September 2015, the US Federal Aviation Administration will review its rules for commercial UAV use – Google, Amazon and FedEx have not yet launched delivery drones in the country because of them. Germany, where DHL launched the first delivery drones in 2014, has already adapted its rules. **Katie Collins**

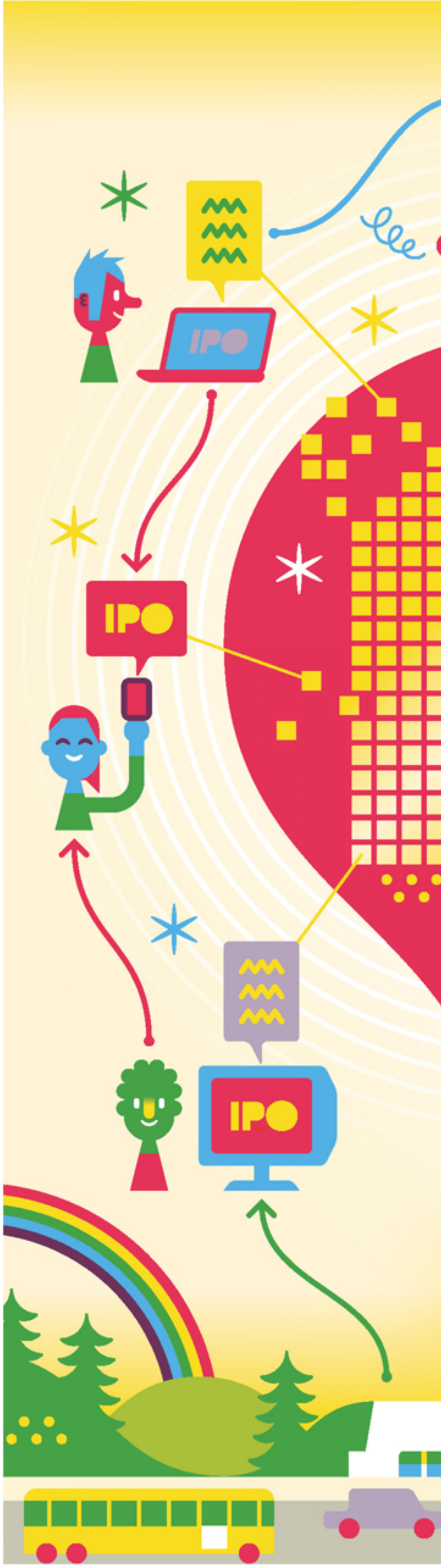


ILLUSTRATION: **STEEBZ**

BYOD

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"Bring your own device" will mature as companies make use of employees' apps, data and social links. By the end of 2015, this will be reflected in 30 per cent of BYOD strategies, says Gartner. KC

for another node, it provides value to the network and receives a safecoin for that service. This safecoin, in turn, can be used by that node to store information in another one.

In Bitcoin 1.0, bitcoin (the currency, denoted by a lowercase b) transactions are keyed on to the Bitcoin (the protocol, denoted by an uppercase B) blockchain, which acts as a distributed ledger. With Bitcoin 2.0 platforms, assets other than bitcoin can now be traded on Bitcoin 2.0 exchanges, making investments fully liquid from day one. In the case of MaidSafe, investors put money into the investment round and received safecoins in return. These investors can sell the safecoins to people who want to use MaidSafe services. This ongoing liquidity is attractive to investors who previously had to wait for an exit event or IPO in order to turn private company shares into money.

By crossing currency and functionality, Bitcoin 2.0 is proving to be an ideal implementation vehicle for networked applications. The pairing of currency and functional usage creates both financial liquidity and usage incentives that together drive the users to promote the platform. Since access is conditioned on a token and the only ways to acquire a token are either to buy one (currency) or to provide value to the network (functional usage), the network becomes a self-reinforcing platform functionally and financially. It is, in essence, its own network effect. Therefore, the more a network is used, the more valuable each token becomes, incentivising each holder of a token to promote the network through word-of-mouth.

Bitcoin 2.0 peer-to-peer networks can also apply to "real world" businesses where the networks are made of things rather than purely computers. An example is Israeli ride-sharing company La'Zooz ("to move" in Hebrew). A basic issue in ride-sharing has been liquidity in providing an incentive for an initial base of users to join and become a service provider for subsequent users. La'Zooz users can install a mobile application that mines ride-sharing coins by monitoring the GPS of their mobile phone. As more density is created and additional users join in any given location, early adopters already have coins accrued to pay for future ride-sharing services. New users who would like to take shared rides can either provide ride-sharing services or buy coins from early investors and other drivers providing rides.

Interestingly, most Bitcoin 2.0 implementations are not US-based. These innovations are headquartered in Europe and Israel and include Colored Coins, Mastercoin, Ethereum and Counterparty. All of these platforms allow the creation of new tokens that will be used by distributed applications. This is happening because the US is riddled with multiple, often contradictory, regulations from different federal and state governing and regulatory bodies – making it more difficult to drive financial innovation.

In recent years, social-proof investment sites such as AngelList have disrupted the venture landscape by providing alternative funding sources to the traditional venture-capital vehicles. In 2015, Bitcoin 2.0 custom currencies will disrupt early-stage investing in a more profound way by combining functionality and liquidity and solving the two hardest problems for startups: monetisation and distribution. So, as regulators play catch-up with the impact of Bitcoin 1.0, 2015 will be a year of consolidation into a winner-takes-all platform and the growth of many initial Bitcoin 2.0 communities.

Eden Shochat is founder and partner at Aleph, an Israeli venture-capital fund. He has no financial connection with MaidSafe or La'Zooz

SHOP ANY TIME, ANYWHERE

The internet hasn't yet killed the high street: by blending the best of online and offline shopping, bricks-and-mortar retailers will find ways to lure in more customers than ever

By **Tej Rekhi**

YOUR TRADITIONAL SHOPPING routines will be replaced by a shop any time, anywhere mentality in 2015. We are already spending more time and money on digital purchases, and integrating the online and offline worlds will expand this behaviour further.

Online retail sales continue to take a larger portion of consumer purchases. According to Forrester, online sales accounted for almost nine per cent of the US's $3.2 trillion retail market in 2013, and this will continue to grow by about ten per cent per year up to 2018.

This rise will be helped in 2015 by a spread of online sales beyond computers and mobile devices, to "real world" applications such as shoppable windows and physical coupons. WeChat, the social networking e-commerce site, will be building its relationship with Tenpay, the Chinese equivalent of PayPal, allowing users to swipe QR codes to buy items such as cinema tickets and beer. WeChat gains revenues from both online and in-store purchases.

In Europe and the US, shoppable windows will give online sites a physical "bricks and mortar" user experience while using digital technology to streamline the purchase process and speed up product deliveries.

In San Francisco, eBay, Rebecca Minkoff and Sony already enable consumers to buy merchandise via touchscreens, pay with PayPal and then arrange for home delivery or pick up in-store. NEO, a youth-oriented Adidas brand in Nuremberg, enables shoppers to touch hotspots on shop windows to view product details and then buy items using their smartphones. The process gathers data about these potential customers and allows them to be targeted with relevant offers. Shoppers who begin their search on mobile devices, for example, will be directed to the closest store with a time-limited coupon to be redeemed against a purchase.

Most consumers will welcome this. Nearly nine out of ten respondents to a recent eMarketer survey claimed they were happy to be tracked by advertisers in return for coupons and special offers.

Customers also like the shorter checkout times online/offline purchasing involves. High street retailers are already using digital ordering to fast track customers to the front of the queue, and online retailers will start to use offline stores to provide same-day delivery or collection services. eBay Now in the US offers same-day delivery on eBay-bought products from local stores. Shutl in the UK, recently bought by eBay, meets a similar consumer impatience.

CHINA LEADS

Crossovers between social networks and retail, via conglomerates such as Alibaba, will make China's e-commerce market worth $540 billion in 2015, according to Citi Research. KC

Digital tools used for browsing, buying and receiving products will translate into greater consumer value. Online shopping makes price comparisons easier, putting more

price pressure on vendors. The added efficiency of digital commerce will reduce overheads, enabling vendors to lower their prices.

In 2015, online and offline will come together to create more value for consumers and retailers. This trend will influence shoppers at every stage of their purchase, from browsing to delivery, changing the way advertisers engage with consumers.

Tej Rekhi is director of product innovation at Sizmek

SPOT ILLUSTRATION: JAMIE JONES

$9BN BY 2015

The predicted size of the consumer e-healthcare market, which will receive a boost from Apple's HealthKit. By 2017, the sector will be worth $15bn, according to the mHealth Bible, produced by Research and Markets. HealthKit's open API allows user data to be shared, creating new businesses opportunities. KC

USING BIOLOGY TO REGULATE STOCK MARKETS

A new understanding of physiological responses to stress could make global financial crises a thing of the past

By **John Coates**

T**HE GLOBAL CREDIT CRISIS AND ITS** aftermath stand as an enduring challenge for economics and finance. Before this event, it was the Crash of 1929 and the Great Depression that stood as the central anomaly that any economic theory had to explain. Today it is increasingly the crisis of 2007-9. Yet economics, finance – and indeed management studies more widely – have had limited success in explaining it. In 2015, the financial world will conclude that it has been working with the wrong models, and will turn increasingly to the biological sciences for help.

Risk managers have been impaired in their ability to understand the crazed risk-taking that led us into the housing bubble, and the hubris and disdain that led countless traders to manipulate the Libor settings, because the models they use are based on two fundamental, and fundamentally wrong, assumptions.

One, these models assume that financial risk-taking – and any activity that takes place in an office – is a purely cognitive activity, requiring the assessment of returns, probabilities and the optimal allocation of capital. But humans do not operate this way. Research in physiology and neuroscience shows that our brains are not built to support pure thought of the kind envisioned by classical economics; they are built to plan and execute movement. In 2015, finance will use this knowledge to make better risk assessments.

When we take risk, even financial risk, we do a lot more than just think about it. We prepare for it physically. Risk by its very nature threatens to hurt us, so when we contemplate it our bodies gird for danger – heart rate and breathing increase, blood is shunted from one set of tissues to others, the immune system is placed on high alert and stress hormones recruit glucose to provide fuel for impending activity. Crucially, these physical changes feed back on the brain and change our mood, the way we think, the very memories we recall. In this way body and brain unite as a single functioning unit.

Perhaps the most important change taking place in our bodies and brains when we take risk is an ebb and flow of our appetite for risk as it calibrates to the levels of opportunity and threat facing us. This point casts doubt on a second assumption underlying our current models of the markets – that risk preferences are a stable trait. They are not. Our appetite for risk fluctuates, and does so under the influence of our biology. Normally, our biology of risk-taking operates exquisitely well, but under circumstances of rare opportunity we allocate more metabolic reserves to risk-taking – much as a hedge fund might allocate more capital to a high-Sharpe-ratio trade (where amount of return is calculated according to the risk associated with it) – and this shows up as increased, even crazed, risk-seeking. When uncertainty and volatility rise for an extended period of time, as it does during a crisis, our stress hormones trigger an increased risk aversion.

It is these biological drivers of risk-taking that risk managers will begin to understand in 2015.

What is emerging from the biological sciences is much more exciting than a new financial theory. The recognition that risk-taking is a highly physical activity opens up economics and finance to the knowledge already existing in the fields of neuroscience, sports physiology and, crucially, medicine.

John Coates, former research fellow at Cambridge University and Wall Street trader, is the author of The Hour Between Dog and Wolf: How Risk-Taking Transforms Us, Body and Mind

FROM THE FACTORY FLOOR TO THE corner office, 2015 will be the year robots make the jump into white-collar work. In 2015, jobs we believed were "safe" will be subject to smart, cheap automation.

In 1841, 22 per cent of the English and Welsh workforce were employed in agriculture and fishing, but by 2011, technology had shrunk that to one per cent. This example is primarily physical in nature; jobs at risk in 2015 will be those requiring creativity, strategic thinking and emotional intelligence.

A recent study of the UK job market by the Resolution Foundation found that between 2008 and 2012 both the top and bottom thirds of the British workforce expanded as the middle third contracted – shedding jobs that are skilled but routine, so subject to automation. Looking at a different data set, John Van Reenen and Guy Michaels from the London School of Economics have noted that in economies with significant information and communication technology (ICT) investment, such as the UK's, middle-class jobs were most eroded, while low-paid, unskilled labour and high-paid, high-skilled labour grew.

These patterns make intuitive sense: low-skill jobs such as food service and

ROBOTS GET NEW JOBS

Thought your job was safe in 2015? Think again. Increasingly sophisticated machines are moving into sectors previously considered to be suitable for human workers only

By **Jake Chapman**

high-skill jobs such as consulting are non-routine and hard to automate. A research report by Kable found that 37 per cent of UK enterprises were planning to increase their ICT spending in 2014, with 75 per cent increasing their investment in business-intelligence tools. This indicates that we should expect to see an acceleration of middle-class, white-collar job losses.

Sophisticated machines will also replace people in medical fields (*see p44*).

In 2011, Watson, IBM's natural-language-processing supercomputer, defeated US quiz show *Jeopardy!*'s champions. In 2013, it could diagnose lung cancer with a 90 per cent success rate compared to 50 per cent for human doctors. In April 2014, IBM made Watson available to US healthcare organisations.

The difficulty of mastering specialised knowledge has previously kept robots out of medicine, but it is their lack of emotional sensitivity that has barred them from other fields. Sweden-based Giraff Technologies has developed GiraffPlus, which combines a robot with a home-based sensor network. The sensors track a patient's movements, their use of appliances, dosage and health indicators. A medical professional can monitor a patient's progress, removing the need for constant in-home care.

Elsewhere, London-based Receipt Bank has developed technology to automatically upload data from receipts and expense reports into the major accounting software platforms, replacing entry-level accountants. The company will expand into the US market in 2015.

Even for creative jobs, automation has begun making inroads. Narrative Science, based in Chicago, has a system that transforms data into natural-language prose – its finance and sports articles are largely indistinguishable from human-written stories. What Narrative Science is doing to writers, a company called Echobox is doing to data analysts. Echobox's technology translates a publication's visitor, article and social data into actionable suggestions. Echobox might suggest shortening the length of a particular article because it has determined that readers abandon it halfway through. These technologies aren't ready to replace editors, but they are competing for entry-level jobs.

Robots won't be entirely replacing the white-collar workforce in 2015, but we are on the edge of perhaps the most dramatic change to the workplace since the Industrial Revolution.

Jake Chapman is VP of strategy for Sazze, an e-commerce incubator based in Santa Clara, California

CROWD CASH

Crowdfunding is set to be worth $17bn in 2015, fuelled by equity crowdfunding and peer-to-peer lending. According to a TABB Group report, platforms will experiment with new models. Projects such as Indiegogo's Forever Funding – which allows campaigns to run indefinitely – will lead the way. KC

MOBILE PAYMENTS

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With PayPal splitting from eBay and Apple launching Apple Pay, in 2015 mobile payments will start climbing steeply, reaching $58.4 billion by 2017, according to Citi Research. KC

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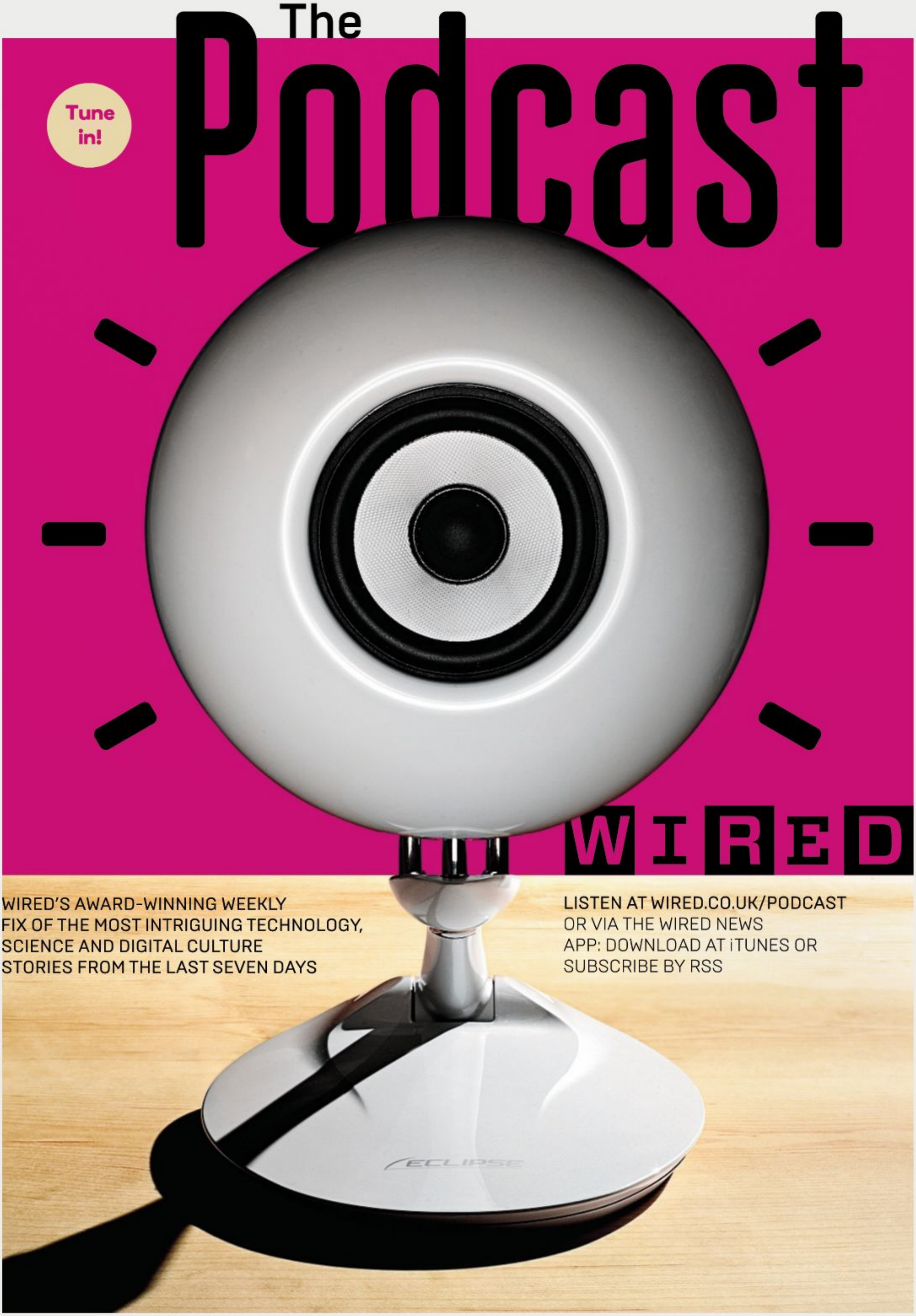

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